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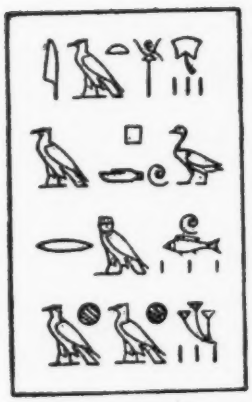

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THE JOURNAL OF WILDLIFE MANAGEMENT

VOLUME 17 OCTOBER 1953 NUMBER 4

ON SCANDINAVIAN LITERATURE IN WILDLIFE MANAGEMENT AND ECOLOGY

Paul L. Errington

Iowa State College, Ames, Iowa

I am not quite ready to urge many busy and practical American wildlifers to learn Scandinavian. I know perfectly well the objections that would be made, having heard them over and over with respect to learning French and German, along with assertions that one cannot find time to keep up with the English-language literature in one's own field! I recognize the real problems imposed by a now-enormous literature on subjects that we all should be conversant with, whether published in English or not.

Undoubtedly, many North American biologists already have some concept of the work carried on by their professional and amateur counterparts in Scandinavian Europe. Many have become acquainted with Danish studies from Kaj Westerskov and with Finnish work from Teppo Lampio. Moreover, there has been a convenient—that is, for us—trend for Scandinavian biologists to publish increasingly in English. A large number of articles that they publish in their own languages have English summaries.

Nevertheless, some of us whose investigations require a knowledge of Scandinavian literature on our specialties have found important publications with no English-language equivalents—not even German-language equivalents. Even when good English (or German) summaries are provided, much of value often remains to be extracted from the Scandinavian text. The really informative discussions may be in the Scandinavian. And, when the English (or German) summaries are inaccurate or sketchy, and are quoted or cited by many authors without checking the texts, their deficiencies may be passed on indefinitely.

In my own reading on vertebrate populations, I have for years studied the publications of F. W. Braestrup and Finn Salomonsen and their colleagues and students at Copenhagen. The Danish-language versions of their work on "cyclic" phenomena, predation, and bird and mammal populations came out in such journals as *Grønlandske Selskabs Aarsskrift, Dansk Ornithologisk Forenings Tidsskrift,* and museum reports as well as in miscellaneous book chapters, etc. The latter include well-written popularizations of modern research findings.

From Norway, some of the publications of Aage Wildhagen have been ex-

tremely interesting to me. One of his major papers is a 192-page review of fluctuations of small rodents (Statens Viltundersøkelser: "Om vekslingene i bestanden av smågnagere i Norge 1871–1949"). This has a seven-page English summary of the classically violent population changes of the lemmings and voles and the evident influence of climatic conditions thereon. The contents of some of his other publications should be equally interesting to many of us, yet, except for quotations, they are published entirely in Norwegian. One that I would mention is an attempt to promote a rational policy of managing the remnant populations of European lynx ("Gaupen, en av våre sjeldne dyrearter", *Fauna, Norsk Zoologisk Forenings Tidsskrift*, No. 3, **1951**: 97–106); an abstract has been accepted by the *Journal of Mammalogy*.

The semi-popular *Suomen Riista* is primarily in Finnish, with Swedish and English summaries, but an occasional article is in Swedish, especially on waterfowl and muskrat management. The substantial Swedish-speaking minority in Finland is further reflected by articles in *Ornis Fennica, Fauna och Flora, Vår Fågelvärld*, and other biological periodicals or bulletins. One of the latest numbers (No. 8, 1952) of *Papers on Game Research*, which is published by the Game Research Institute of the Finnish Game Foundation, reports a conference of game biologists of Scandinavia and Finland; and it has as much space devoted to the Scandinavian languages (mostly Swedish) as to English, German, and Finnish combined.

Among the Swedes in Sweden, Gunnar Svärdson, who is an ichthyologist and ornithologist, has made most valuable contributions to the literature on competition in vertebrate populations. A great deal of what he has written is in English but there are still advanced concepts, data, and discussions in his Swedish-language articles. Einar Lönnberg's "Svenska Fåglar", one of the outstanding regional bird works of the world, has material in it that should be consulted by anybody studying northern birds having circumpolar distribution. I have been informed that Rudolf Söderberg's "Hornborgasjöns Öden som Fågelsjö" (Stockholm, 1947) is an excellent detailed account of the consequences of drainage to bird life, and this would seem timely reading to American marsh managers.

Big variations in interest and significance occur in Scandinavian publications as well as in our own, but there certainly is much in them that deserves careful reading by people having special reasons or needs for following the researches of the Scandinavians in special fields.

The rest of this article is directed to those who might find it advantageous to learn to read some Scandinavian, and it is for the sake of these that I shall next summarize my own experience with the languages.

Actually, my hardest specific job in this connection was to make up my mind to learn some languages other than the French and German customarily required for the Ph.D. in biological sciences. Years ago, I discovered that I could get the gist of some Dutch and Danish by sounding out the words and thinking in terms of what I knew of the related German and Old English. Occasionally, I could make out a whole sentence or most of a paragraph of a

"key" passage without reference to a dictionary; then again, I would run into something that I could not figure out at all, irrespective of how much I looked in a dictionary. I always had trouble with the common "little words." I also had rather parallel successes and difficulties in trying to read Spanish and Portuguese from a background of French and "picked-up" Latin. Frederick Bodmer's "The Loom of Language" (W. W. Norton and Co., N. Y., 1944) was very helpful in teaching me to follow word relationships in the Teutonic and Latin groups of languages.

Similarities of words in a language group can, on the other hand, be misleading. One Norwegian word, "beskytte", means to protect and another, "beskyte", means the opposite. I got some peculiar impressions of what an author was conveying before I learned to distinguish between the two. I still believe that the method of sounding out and endless reference to a dictionary has utility for one who has only a very limited amount of reading to do in a given language; but, for one who has much reading to do, any method falling short of learning elementary grammar and vocabulary is difficult and unrewarding.

I should confess that, along with my monolinguistic countrymen, I can speak or compose only English, except for ridiculously poor French, German, and Norwegian. I am no linguist in the sense that a genuine linguist would admit, and I suppose that the average student in a Scandinavian university knows my language (plus two or three other languages foreign to him) far better than I know his. Hence, what I have done in acquiring a reading knowledge of Scandinavian should be within the power of so many people that any prospective learners may appropriately be encouraged. The chief difficulties lie in our assumptions that the tasks must be more formidable than they are.

My start in learning Scandinavian "from scratch" was slow, with plenty of drudgery—partly, presumably, because of my being past the age when learning processes, *per se*, are easiest. I know the annoyance of having to look up a visually familiar word again and again before it finally sticks. Of course, I have had the advantage of decades of toiling over German.

My transition from complete dubhood to fairly comfortable proficiency in reading at least Norwegian cost an average of about three hours a week for a year. This, in my opinion, was anything but an excessive expenditure of time and effort for the benefits gained. I can not see that it ever interfered with my regular professional duties, as I did it all during waits in depots, garages, for appointments, etc., or in evenings when not overly tired for an hour or two of leisurely study. Sometimes, I would not do anything on it for a couple of weeks at a stretch; at other times, when I felt like it, I would put in eight or ten hours in the evenings of a single week. It was low-intensity, off-and-on work, and I never pushed myself to study after an exacting day, but it counted up in the end more than I originally had any hopes that it would. Now, I feel that it has the momentum to keep going almost by itself, and I am coming to enjoy it as a hobby.

I chose Norwegian as the Scandinavian language upon which to concentrate because of its intermediate position

between Danish and Swedish, and, of the Norwegian dialects, I concentrated on Dano-Norwegian. My reading of recently modernized Norwegian was much facilitated by the use of Theodore Jorgenson's "Norwegian-English School Dictionary" (St. Olaf College Press, 1943).

The alternative spellings of Norwegian words became less confusing as "feel" of the language was gained, and, throughout my studies, I found it of fundamental importance to learn as nearly correct pronunciation as my English-speaking tongue could manage —in which I was greatly helped by Norwegian-speaking friends. As a rule, I follow pronunciation in my mind and do as little direct translating as possible unless the meaning is uncertain. Through this "mental sounding", Twentieth Century Norwegian falls into pattern, whether the dialect uses "d" for "t", "g" for "k", "e" for "ae", whether a letter is interchangeably an "aa" at the first of an alphabet or an "å" at the last, whether words have letters that are silent in one dialect or spelled phonetically in another. Furthermore, through increasing familiarity with the relative constancies in Norwegian sound patterns, I have been better able to undertake the reading of Danish and Swedish.

Of the latter two, Danish is for me much the easier to read from my background of Norwegian. The much different spelling of Swedish had enough strangeness for me so that for a long time I almost had to test it word for word to get the familiar Scandinavian sound patterns. And Swedish shows rather big differences in other ways; it is distinctly a separate language and one does not automatically acquire proficiency in it just by learning Norwegian or Danish. My first feelings of any proficiency in reading Swedish came after about six months of systematic study that was superimposed upon an ample background of Norwegian.

As languages of western Europe go, the Scandinavian have a blessed simplicity of structure for readers accustomed to English. I haven't encountered anything in them that begins to compare either with ponderous scientific German or idiomatic French. The Scandinavian languages, too, may have idioms that don't translate out verbatim, and Scandinavians, being human, may likewise compose ambiguous and cumbersome sentences, the same as the rest of us may in our respective languages, but the Scandinavian should surely be classed as among the readable languages.

One procedure has been helpful to me, I think, in learning languages in the Teutonic group: the reading of simple tales in the original language. In studying German years ago, I wished to have something to read before bed time, something not taxing for a tired head, yet mildly entertaining and contributing some degree of regular practice; so I would sit a couple of hours an evening with a book of fairy stories, soaking up German via the fantasies of elves, ogres, talking beasts, naive humans, and happy endings. I have done a little reading of Asbjörnsen and Moe in Norwegian and am anticipating trying out Hans Christian Andersen in the Danish. Incidentally, I have noticed that the German and Scandinavian versions of some of these stories are much more cleverly written, tongue-in-cheek, and pleasantly heathenish than their denatured English translations. Carefully selected, they

can be fun for people who do not feel scornful of this sort of reading or obliged to be serious-minded all of the time.

Other suggestions that might be made include practicing on taxonomic papers to begin with. Terse descriptive passages are easier to read than complex discussions. The use of scientific, medical, or hunters' dictionaries (I know of a Svensk Jaktlexikon and a two-volume Dansk Jagtleksikon) may be necessary for technical reading, as it is frequently impossible to find a technical word or its root in one of the smaller literary or conversational dictionaries. A beginner may learn from studying bilingual publications such as Salomonsen's "Grønlands Fugle; The Birds of Greenland", with text in Danish and in English on opposite columns of each page.

Indeed, I have been getting a small start in learning some Finnish from bilingual (Finnish - Swedish) illustrated articles on identification of game and raptorial birds published in *Suomen Riista*. I am not sure that I shall ever read Finnish, but hope to learn enough terms so that I may, as a minimum accomplishment, recognize what is being written about and so have a basis for selecting paragraphs or sections of Finnish-language publications for the attention of a competent translator. Learning even a smattering of a new language always is advantageous to this extent.

In short, I would advise anyone who feels that he ought to do something about Scandinavian-language literature (or anyone who feels disposed to learn to read Scandinavian for any purpose) to go ahead and tackle it, if but a little now and then. One need not set up an objective of acquiring an unlikely fluency in Scandinavian to make study worth while. If I am entitled to judge, I would say that a modest competence in these languages yields much satisfaction. And if one did not go far with such a course, I would still say that one should gain from starting it.

PERSONAL ACKNOWLEDGMENTS

This article has been something of a cooperative venture, and I have received encouragement and advice from many people. Among those who have read critically earlier versions of the manuscript and made suggestions are Dr. Donald S. Farner of the State College of Washington, Dr. Randolph L. Peterson of the Royal Ontario Museum of Zoology and Palaeontology, Doctors Oliver H. Hewitt and Gustav A. Swanson of Cornell University, and, here at Iowa State College, Doctors R. E. Buchanan, Kenneth D. Carlander, H. M. Harris, Ellis A. Hicks, E. L. Kozicky, and E. Frode Lind. Finally, I am grateful to Mrs. Margaret Morse Nice, of Chicago, for her personal example of years ago in learning more languages in order better to explore the European literature on life history, behavior, and population phenomena of vertebrates.

THE IMPORTANCE OF BEAVER IN WATERFOWL MANAGEMENT AT THE SENEY NATIONAL WILDLIFE REFUGE [1]

Elizabeth B. Beard

School of Natural Resources, University of Michigan, Ann Arbor, Michigan

EDITOR'S NOTE: Articles which will occupy more than 20 pages in the *Journal* are not usually accepted for publication by The Wildlife Society. Occasionally, more lengthy papers can be published when authors pay the cost of the pages exceeding 20.

This article is the result of a long study by Mrs. Beard. It will be of much interest to persons concerned with wildlife ecology and management. Publication has been made possible in the *Journal* by a subsidy from the *Wildlife Management Institute*. Appreciation is expressed by the Society to the Institute, and particularly to Ira N. Gabrielson and C. R. Gutermuth.

INTRODUCTION

The praises of the beaver as nature's engineer are frequently sung, and the use of beaver ponds by wildlife, especially ducks, is asserted to be both common and widespread. A search of wildlife literature, however, reveals no detailed studies that substantiate such assertions. This fact is emphasized by Evans (1948). Recognition, however, is paid the beaver as creator of desirable waterfowl habitat by Bradt (1947), Bump (1941), Carr (1940), Cook (1940), Foote (1945), Grasse and Putnam (1950), Moore and Martin (1949), Salyer (1935), Shaw (1948), Swank (1949), and others.

The three-fold purpose of this report, based on field work carried on at intervals over three years at the Seney National Wildlife Refuge, is: (1) to demonstrate that the beaver is entitled to praise as a wildlife engineer and that beaver ponds in marsh country such as that at the Seney Refuge are intensively used by waterfowl; (2) to ascertain the

[1] Field data were largely obtained during the writer's term of employment with the Fish and Wildlife Service in 1947-1949.

The author wishes to express sincere thanks to the Wildlife Management Institute, which provided funds to make possible the publication of this paper.

The author is also indebted to the many people who contributed so freely of their time and knowledge toward the preparation of this paper. Especial appreciation is expressed to the late C. S. Johnson, former refuge manager of the Seney Refuge, who maintained a keen interest in the project at all times and who generously shared many of his ideas on the relation of beaver to waterfowl habitat; to Richard E. Griffith, Fish and Wildlife Service, for constant encouragement and helpful advice; to Harvey Saunders, Seney Wildlife Refuge, for much valuable information on early conditions in the Seney marshes and for guidance through much of the remote parts of the refuge; to Frederick J. Hermann, Bureau of Plant Industry, Neil Hotchkiss and Francis M. Uhler, Patuxent Research Refuge, Dr. and Mrs. Justin W. Leonard, Michigan Department of Conservation, and Karl F. Lagler and Henry van der Schalie, University of Michigan, for identification of various items; to Warren W. Chase and Samuel A. Graham, University of Michigan, for helpful suggestions and a critical reading of the manuscript; and to A. S. Beard, who unselfishly spent his entire vacation in 1949 assisting the writer in collecting field data.

factors responsible for the attractiveness of beaver areas to waterfowl; and (3) to suggest measures to ensure the continued presence of beaver ponds and to aid artificially in establishing similar areas.

SITE OF STUDY

The Seney National Wildlife Refuge is located in Schoolcraft County in the eastern part of the Upper Peninsula of Michigan. Its 96,000 acres contain a major portion of the extensive Seney marshes.

The passage of time has left slight impression on much of this marshland. It remains little changed from its original condition. According to Harvey Saunders, who began cruising this country in 1900 and who has been on the staff of the Seney Refuge for many years, much of the big pine has gone, but the marsh now, as then, extends vast and undisturbed, broken only by numerous pine-covered sandy knolls and ridges. The long axis of the marshes, of the ridges, and of the six creeks that flow through parts of the refuge lie with rather marked conformity in a northwest-southeast direction. Sedges characteristic of semi-dry soils continue to be the dominant vegetation. Their growth is rank and dense. With the exception of the streams, originally there was little open water. Conditions varied with the annual precipitation, but, in general, few openings occurred in the lush sedge vegetation. Because of this, waterfowl and beaver were scarce. The few beaver usually lived in banks along the creeks. Sometimes their dams across these streams formed small ponds, which were utilized by small numbers of waterfowl.

In 1935 the Fish and Wildlife Service acquired this marshland for a wildlife refuge. One of the first acts was to divert water from streams, such as the Driggs River, to the dry marshes. Dikes were built to impound pools of varying size. Nineteen pools, totaling approximately 6,500 water acres, were constructed during a six-year period. This development (with the exception of one pool) has been confined so far to the eastern third of the refuge comprising Units 1 and 2. The remaining 66,000 acres, (known as Unit 3) are still undeveloped and unchanged.

In Units 1 and 2 the effect of the pools and of the increased amount of water spreading gradually outward has become noticeable. The marshes have begun to change. Sedge here and there is being replaced by cattail; bulrush has commenced to appear. Little by little the old semi-dry sedge marsh is becoming wet marsh. In response to this changed environment waterfowl populations have expanded with increasing rapidity with passing years. Beaver have established themselves over much of this newly-flooded area. Now (1949) waterfowl and beaver occupy the suitable portions of Units 1 and 2 in significant numbers.

PLAN AND OBJECTIVES OF STUDY

In the spring of 1947 the author was assigned to the Seney Refuge to investigate use by waterfowl of the various types of habitat. It was thought that if the environmental types most favored by waterfowl and the reasons for such preference could be determined, management efforts could then be directed toward increasing the acreage of preferred types.

It was soon discovered that certain

types of marshes and small ponds were preferred by ducks during spring and early summer for breeding activities. It was also quickly realized that these types of marshes and small ponds were almost always the result of past or present beaver activity.

In order to investigate the relation of beaver to habitat receiving intensive use by waterfowl, four areas typical of refuge habitat and embodying different stages in beaver activity were selected for detailed study.

The general plan of procedure was three-fold: (1) every attempt was made to keep these areas under close observation to determine their use by waterfowl; (2) physical characteristics of the areas were very carefully analyzed to determine the important factors responsible for their attraction to waterfowl; (3) management recommendations were designed to maintain a desirable number of such beaver ponds and marshes.

STUDY METHODS AND TECHNIQUES

From favorable sites on natural ridges and dikes that bordered and overlooked the study areas, direct observations with 8x binoculars and 20x spotting 'scope were made of the ducks' activities. Early morning or late afternoon was found to be best for watching, since the ducks were then most active. A daily record was kept of data on species, number of individuals, size of broods, age class of young, behavior of young, and behavior of adults. To facilitate observations on Study Area IV, a platform was constructed at a height of about 30 feet in a red pine. This permitted a view of the entire marsh.

Rough maps, based on aerial photos when possible, were drawn of each study area, and field data sheets were prepared, so that measurements and other information could be quickly recorded. Stakes were driven and cord strung to form transect lines across each area. There were four or five of these lines (depending upon the size of the marsh or pond) erected parallel to each other, locations being plotted on the field maps. At regular intervals along each line (usually four to six, depending upon the length of the line) the following measurements and samples were taken and recorded on the field data sheets: (1) depth of water; (2) sweep of insects on emergent vegetation; (3) sweep of insects in water and on marsh or pond bottom; and (4) amount and kind of submerged aquatic plants. The space occupied by emergent vegetation and by open water along the length of the transect line was measured to the nearest half-foot.

The density of emergent vegetation was also recorded. Based on the ease with which ducks could penetrate it, three degrees of density (sparse, medium, and dense) were set up. A series of 32 stem counts, each along a 36-inch line, were made at random in several marshes. Growth which offered no hindrance and only scant cover to waterfowl was labeled sparse. Stem counts taken in such areas ranged from 0 to 160. Vegetation which allowed easy penetration by waterfowl and which provided abundant escape cover was classified as medium, with stem counts from 160 to 290, but with the majority between 240 and 265. Vegetation with stem counts above 290, which could not be penetrated by waterfowl, was called dense. With a little practice, it was possible to classify the degree of density of the emergents with

reasonable accuracy, so that it was not necessary to make stem counts, except occasionally for checking estimates.

The presence of other forms of wildlife and the plants along the periphery of these marshes and ponds were noted and all important species were recorded with estimated densities.

As a further aid in analyzing these four marsh areas, enlargements of air photos taken in 1938 were used for comparison with air photos of the same locations taken in 1949 by the author. In addition, pictures were taken from the ground to show various types of cover interspersion, beaver activities, etc.

WATERFOWL USE OF STUDY AREAS

It was soon established that waterfowl were using the four study areas quite intensively. This heavy usage, although it varied somewhat in response to changes in local conditions, continued throughout the entire period.

STUDY AREA I was a sedge marsh which had been abandoned by beaver for either three or four years. Its record of waterfowl use for the three-years' study follows.

Nesting. No nests around the periphery of this marsh were discovered. One brood each of very young black ducks, blue-winged teal, and hooded mergansers, suggest that nests were nearby.

Broods. Table 1 summarizes the brood observations for this area over the three-year period.

The most numerous broods were of black duck, blue-winged teal, and mallard. Total duckling production for the marsh was 108.

The ease and speed with which broods disappeared into the nearby sedge at the approach of any would-be observer, demonstrated its adequacy and effectiveness as escape cover.

The length of time which individual broods remained in the marsh was difficult to determine, for none of the ducklings were marked. Sometimes it was possible, however, to identify broods with reasonable accuracy. Observations of these showed that they remained in the marsh from two to four weeks. One brood of black ducks first seen on May 27 as downy young was later recorded May 28, June 2, June 23 and June 30. A brood of blue-winged teal was followed through from July 5 to July 22, and another from July 19 to August 2.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the

TABLE 1.—NUMBER OF DUCK BROODS USING STUDY AREA I
(SEEPAGE MARSH ABANDONED BY BEAVER)

	1947		1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Mallard	2	9	1	7	1	7	4	23
Black duck	5	34	1	5	0	0	6	39
Blue-winged teal	3	22	2	12	1	6	6	40
Hooded merganser	1	6	0	0	0	0	1	6
Total	11	71	4	24	2	13	17	108

three-year period is summarized in Table 2.

TABLE 2.—NUMBER OF ADULT DUCKS USING STUDY AREA I
(SEEPAGE MARSH ABANDONED BY BEAVER)

Species	1947	1948	1949	Total
Mallard	52	18	16	86
Black	88	64	20	172
Baldpate			3	3
Pintail	1			1
Green-winged teal	22		2	24
Blue-winged teal	57	43	20	120
Wood duck		4		4
Ring-necked duck	7		2	9
Hooded merganser	16	2	1	19
Total	243	131	64	438

Black ducks, blue-winged teal and mallards were the ducks most commonly seen in the marsh in each of the three years. They accounted for about 85 per cent of the total of 438 observed.

A variety of activities was engaged in by these ducks. In late spring, territorial activity of male mallards, blue-winged teal, hooded mergansers and black ducks was noted. During this period, drakes of these species were frequently observed loafing or feeding in parts of the marsh.

Throughout June and July, in addition to hens with broods, small numbers of ducks were often seen feeding in the marsh. By September and October as many as five to ten at a time of mallards, blacks, or blue-winged teal were feeding there. Green-winged teal and ring-necks were not seen in Area I after the middle of June.

No evidence of the use of this marsh by moulting adult ducks during their flightless period was discovered.

STUDY AREA II was a sedge marsh flooded by a beaver dam across the creek which runs through the area. Its record of waterfowl use for the last two years of the study period follows.

Nesting. On May 30, 1949, a hen wood duck was flushed from a nest with 9 eggs in a keg nailed to a dead jack pine (*Pinus banksiana*) standing in the marsh about 75 feet from shore. On June 9, all but two eggs had hatched. When opened, these contained embryos almost fully-developed. Another nesting keg in a dead jack pine standing in the marsh about 300 feet from shore contained a great deal of down, but no eggs. This may have represented an earlier nest of wood ducks that was broken up, or might have been the successful nest of another tree-nesting species, such as hooded merganser.

One brood each of very young blue-winged teal and hooded mergansers was seen, indicating nests in the immediate vicinity.

Broods. Table 3 summarizes the brood observations for this area over a two-year period (1948 and 1949).

TABLE 3.—NUMBER OF DUCK BROODS USING STUDY AREA II
(RIVER MARSH DAMMED BY BEAVER)

	1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young
Black duck	1	5	1	10	2	15
Blue-winged teal	1	3			1	3
Wood duck	2	14			2	14
Hooded merganser	1	1	2	18	3	19
Unknown	1	5			1	5
Total	6	28	3	28	9	56

Broods of hooded merganser, black duck and wood duck were found in the marsh in the greatest number. The total production of ducklings for the two years was 56.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the two-year period is summarized in Table 4.

TABLE 4.—NUMBER OF ADULT DUCKS USING STUDY AREA II
(RIVER MARSH DAMMED BY BEAVER)

Species	1948	1949	Total
Black duck	1	11	12
Blue-winged teal		1	1
Wood duck	6	23	29
Ring-necked duck	5	16	21
Hooded merganser		3	3
American merganser		2	2
Total	12	56	68

Wood ducks and ring-necked ducks were commonest in this river marsh for the two-year period. Together they accounted for more than two-thirds of 68 ducks seen.

During the late spring the repeated presence of single black ducks, wood ducks and hooded mergansers loafing and feeding in the area suggested that territories had been set up. Pairs of ring-necks were observed in the area feeding and loafing during the first half of May. On three occasions (June 28, July 12 and 22) a total of 12 flightless adult black ducks and wood ducks were observed.

STUDY AREA III was an open-water beaver pond which has been maintained off and on by beaver for many years. Its record of waterfowl use for the three-year study period is given below.

Nesting. One brood of downy black ducks and two of ring-necks, indicate nesting in the immediate vicinity.

Broods. Table 5 summarizes the brood observations for this area over the three-year period.

Black duck, ring-necked duck, and hooded merganser broods were each present in equal numbers in this beaver pond for the three-year period. They accounted for three-quarters of the total number of broods seen. The duckling production for this pond was 102.

A series of observations of individual broods that could be identified indicated that these remained in the pond from one and one-half weeks to six weeks. One black duck brood was recorded four times, between June 14 and July 28. A ring-necked brood was seen July 8 to July 18 and a hooded merganser brood from June 14 to July 8.

TABLE 5.—NUMBER OF DUCK BROODS USING STUDY AREA III
(OPEN-WATER BEAVER POND)

	1947		1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Mallard					1	3	1	3
Black duck	2	15	3	23			5	38
Blue-winged teal					1	6	1	6
Wood duck	2	9					2	9
Ring-necked duck	3	20			2	7	5	27
Hooded merganser	2	8	1	2	2	8	5	18
American merganser					1	1	1	1
Total	9	52	4	25	7	25	20	102

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this pond for the three-year period is summarized in Table 6.

TABLE 6.—NUMBER OF ADULT DUCKS USING STUDY AREA III (OPEN-WATER BEAVER POND)

Species	1947	1948	1949	Total
Mallard	2	11	11	24
Black duck	15	29	19	63
Pintail			6	6
Green-winged teal		15	8	23
Blue-winged teal	7	19		26
Wood duck	1		3	4
Ring-necked duck	15	18	7	40
Hooded merganser	3	8	5	16
Total	43	100	59	202

Black ducks and ring-necks were the commonest ducks in the beaver pond for the three-year period. They accounted for half of 202 ducks seen.

The presence of pairs or singles of black ducks, blue-winged teal, ring-necks, and hooded mergansers during May and June indicated that territories had been set up.

During the early part of May this pond was used by small numbers of migrating pintails, green-winged teal, ring-necks and mallards. From the end of July to September, mallards, blacks, blue-winged and green-winged teal flocked for feeding into the area in numbers varying from 10 to 15 each. An occasional wood duck and hooded merganser were recorded during late summer. On July 28, 50 ducks of these four species were observed. That they had been there for several days was indicated by a blanket of duck feathers along the edge of the occupied cove.

STUDY AREA IV was a seepage, sedge marsh which has been maintained by beaver for many years. Its record of waterfowl use for the three-year study period follows.

Nesting. One brood each of very young black ducks, baldpates, ring-necks and hooded mergansers indicate nesting in the area. Due to low return for time spent, little effort was concentrated on searching for nests.

Broods. Table 7 summarizes the brood observations for this area over the three-year period.

In order of abundance, broods were of hooded merganser, black, baldpate, ring-necked and wood duck. The total

TABLE 7.—NUMBER OF DUCK BROODS USING STUDY AREA IV (SEEPAGE MARSH MAINTAINED BY BEAVER)

	1947		1948		1949		Total	
Species	No. broods	No. young	No. broods	No. young	No. broods	No. young	No. broods	No. young
Black duck	1	3	1	4	2	15	4	22
Baldpate			2	10	2	8	4	18
Blue-winged teal			1	8	1	4	2	12
Wood duck			2	8	1	4	3	12
Ring-necked duck					3	20	3	20
Hooded merganser	1	7	2	16	2	17	5	40
Total	2	10	8	46	11	68	21	124

production for the marsh was 124 ducklings.

Repeated observations of individual broods showed that they were remaining in the marsh from one to four weeks. One brood of baldpates first recorded on June 28 as downy young, was later seen on July 1, July 13, and July 29. A brood of black ducks was followed through from May 24 to June 9. One brood of ring-necks was checked from June 27 to July 12, and another of the same species from June 27 to July 5.

Adult activities. The number of adult ducks (omitting hens accompanied by their broods) using this area for the three-year period is summarized in Table 8.

TABLE 8.—NUMBER OF ADULT DUCKS USING STUDY AREA IV
(SEEPAGE MARSH MAINTAINED BY BEAVER)

Species	1947	1948	1949	Total
Mallard	2	5	2	9
Black duck	23	48	90	161
Baldpate	7	12	19	38
Green-winged teal	1			1
Blue-winged teal	15	6	5	26
Wood duck	15	40	65	120
Ring-necked duck			17	17
Hooded merganser	7	2	2	11
Total	70	113	200	383

Black ducks and wood ducks were the most frequently observed ducks in the marsh for each of the three years. They accounted for more than two-thirds of the total number of 383 seen.

By late spring, territories had been established by blacks, baldpates, blue-winged teal, ring-necks, and hooded mergansers.

Throughout the summer months black ducks, baldpates, and wood ducks were observed feeding in the marsh in numbers varying from three or four of one species at a time to as high as 40. In August, blue-winged teal and ring-necks in small numbers appeared in the marsh to feed. With the exception of a few blacks and mallards seen in October, the area was largely abandoned by ducks after the first of September.

On several occasions in June and July of 1948 and 1949, flightless black and wood ducks were flushed at very close range. A total of eight black ducks and ten wood ducks were observed in the flightless stage of the post-nuptial moult in this sedge marsh.

A summary of the waterfowl observations made in these four study areas showed that they were providing (1) sites for the establishment of territories by paired ducks; (2) cover and food sufficient for rearing broods; (3) an adequate source of food for adult ducks in small numbers especially during the late summer and early fall. In addition, one area furnished suitable nest sites for tree-nesting species at least, and two supplied the necessary food, escape cover, and isolation needed by black and wood ducks during the flightless period of their post-nuptial moult.

ENVIRONMENTAL ANALYSIS OF STUDY AREAS

To determine why these areas were being used by waterfowl, a detailed environmental analysis of the physical characteristics of the areas was carried on in the summer of 1949. The procedure and methods have already been discussed.

STUDY AREA I was a sedge marsh of approximately 10 acres located in the NW1/4 sec. 21, T. 45 N., R. 13 W. It

is just southeast of F Pool in Unit 1 of the Refuge.

During 1944 and 1945 (and perhaps earlier) beaver were inhabiting this marsh. Where the two drainage ditches converged and the water passed on through a natural channel, they maintained a dam 45 feet long and 3 feet high. The actual pool formed was not over 30 feet in diameter, but the dam greatly retarded the water passing out of the area and quite effectively increased the water level over the marsh. A rather small lodge was on the bank at the edge of the pool. Numerous canals had been dug by the beaver to facilitate the utilization of the aspen growing on the ridge along the south side of the marsh. Beaver cuttings were abundant. By the spring of 1947 the beaver had abandoned the area.

By 1949 the lodge was almost entirely flattened, and the dam was no longer effective. The pool held a small amount of water in the spring, but was completely dried out in the summer and was growing up to burreed (*Sparganium* spp.). Evidence of much old beaver cutting on tag alder (*Alnus incana*), juneberry (*Amelanchier* spp.), white birch (*Betula papyrifera*), and poplar (*Populus* spp.) was visible along the surrounding ridge, but no sign of active beaver was found. Significantly, not one live aspen remained on the ridge. This suggested that it was lack of food which forced the beaver to abandon this area.

This ten-acre marsh is bounded on the north by a sandy ridge which extends eastward as a peninsula from the dike road and on the east by one of the old drainage ditches, now blocked at both ends, so that it no longer carries water away. Along the south side is a long ridge the appearance of which suggests that it might be a very ancient beaver dam. On the west is a ridge which parallels the F Pool dike road. All ridges are narrow. That on the south is barely above the marsh. Those to the north and west are considerably higher.

Jack pine and red pine (*Pinus resinosa*) grow on the ridges. Spruce (*Picea glauca*), tamarack (*Larix laricina*), white birch, a few cedar (*Thuja occidentalis*), and red maple (*Acer rubrum*) are present on the south ridge, showing the influence of the lower elevation. Juneberry, viburnum (*Viburnum* spp.), and tag alder are common on all the knolls, and blueberry (*Vaccinium* spp.), bracken (*Pteris aquilina*), and sweet fern (*Myrica asplenifolia*) provide the ground cover. In the peripheral zone between the base of the ridges and the marsh proper, thick cover is provided by clumps of leatherleaf (*Chamaedaphne calyculata*), bluejoint grass (*Calamagrostis canadensis*), manna grasses (*Glyceria canadensis* and *G. borealis*), sedge (*Carex lasiocarpa*), bulrush (*Scirpus atrocinctus*), cattail (*Typha latifolia*), and burreed (*Sparganium eurycarpum*).

A rather fine sedge (*Carex lasiocarpa*) is the dominant emergent growing in the marsh, where its stems form not tussocks but beds of the type frequently known as "sedge meadows." Other sedges (*Carex chordorrhiza*, and *C. rostrata* and *Eriophorum* sp.), bluejoint grass, and rush (*Juncus canadensis*) occur in insignificant amounts.

A series of measurements of marsh cover yielded information on amount, composition and degree of interspersion of the emergent vegetation in the marsh (Figs. 1 and 2).

The method of determining the amount

and composition was as follows. Emergent growth and open water were classified into cover types. This was based not necessarily on species, but on degrees of density, on gross physical differences, on possible differences in use by waterfowl. For example, each of three degrees of density of sedge constituted a separate cover type. It was irrelevant whether the sedge was all of one species or not—provided it was of the same density. A solid stand of burreed was classed as another type, since it might be used for a purpose peculiar to itself by waterfowl. Dead brush was another cover type, while live bushes, such as leatherleaf, was yet another. Combinations, such as sedge and brush, sedge and cattails, and leatherleaf and dead trees were likewise regarded as distinct cover types.

Transect lines equidistant and parallel across the area were used as sampling bases. Each was measured, and the amount occupied along it by each cover type. From these measurements both the total number of feet occupied by each type and the per cent of the transect line which this represented were computed.

When these measurements were combined for all transects, the total amount occupied by each type and the per cent of the total transect lines which this represented were obtained. Since this combined transect line represented a cross-section of the entire marsh, the per cent of it which each cover type occupied approximated the per cent of the entire marsh which each cover type comprised.

Figure 1 shows that there are two general zones in the marsh. The first is open water with a few isolated clumps of dead brush. This accounts for about one-third of the study area. The second is sedge marsh well broken up by water into small units, and constituting the remaining two-thirds of the area. Within this sedge marsh zone, water represents approximately one-quarter of the acreage, or a ratio of water to cover of 1:3. All three degrees of density are found in the sedge, but the amount classified as dense (*i.e.*, unusable by waterfowl) is small, whereas the amount of sparse and medium is seven times as great, or slightly over half of the entire sedge marsh zone.

The method of determining the degree of interspersion was based on the idea that interspersion is a mixing of environmental types, and that its amount is determined by the number of times the cover types occur. In order to express this numerically, the total number of occurrences in a specified unit such as along a given line, was divided by the number of cover types present in the unit. The result was the numerator in the "Index of Interspersion." For example, if within a certain area, each cover type occurred but once, interspersion would be at a minimum, and the numerator would be one. If within this area, the cover types occurred more frequently, the numerator would be higher—thus indicating a greater degree of interspersion.

Another factor, which is expressed as the denominator in the "Index of Interspersion," is the size of the units of cover. Although two areas might have the same degree of interspersion, and consequently the same numerator, if the average size of the cover units is six inches in one and sixty yards in the other, it is apparent that the kind of interspersion would be radically differ-

ent in the two areas, which the respective denominators of 6 inches and 60 yards would show.

It is obvious that the size of a unit of cover type determines to a considerable extent its potential use. For example, blocks of vegetation averaging six inches long would have little utility as cover for waterfowl, whereas those averaging six feet would have extensive use. Therefore, the inclusion of the average size of the cover type units as

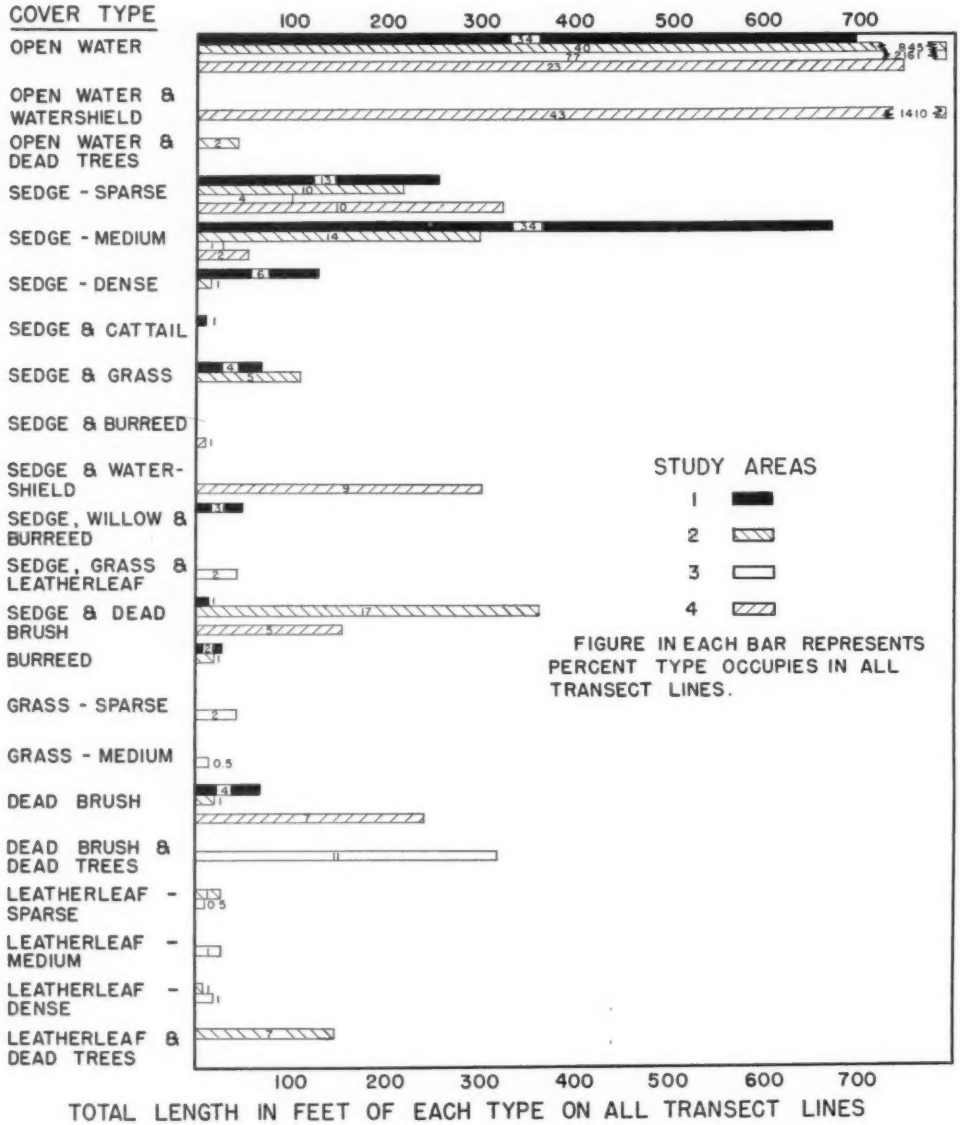

FIG. 1. Amount and composition of emergent vegetation and water for the four study areas.

part of the "Index of Interspersion" renders possible a much more accurate and complete expression of the interspersion. By the use of such an index, it is also possible to compare the interspersion of various areas both as to degree and kind. The denominator—the average size of the cover type units

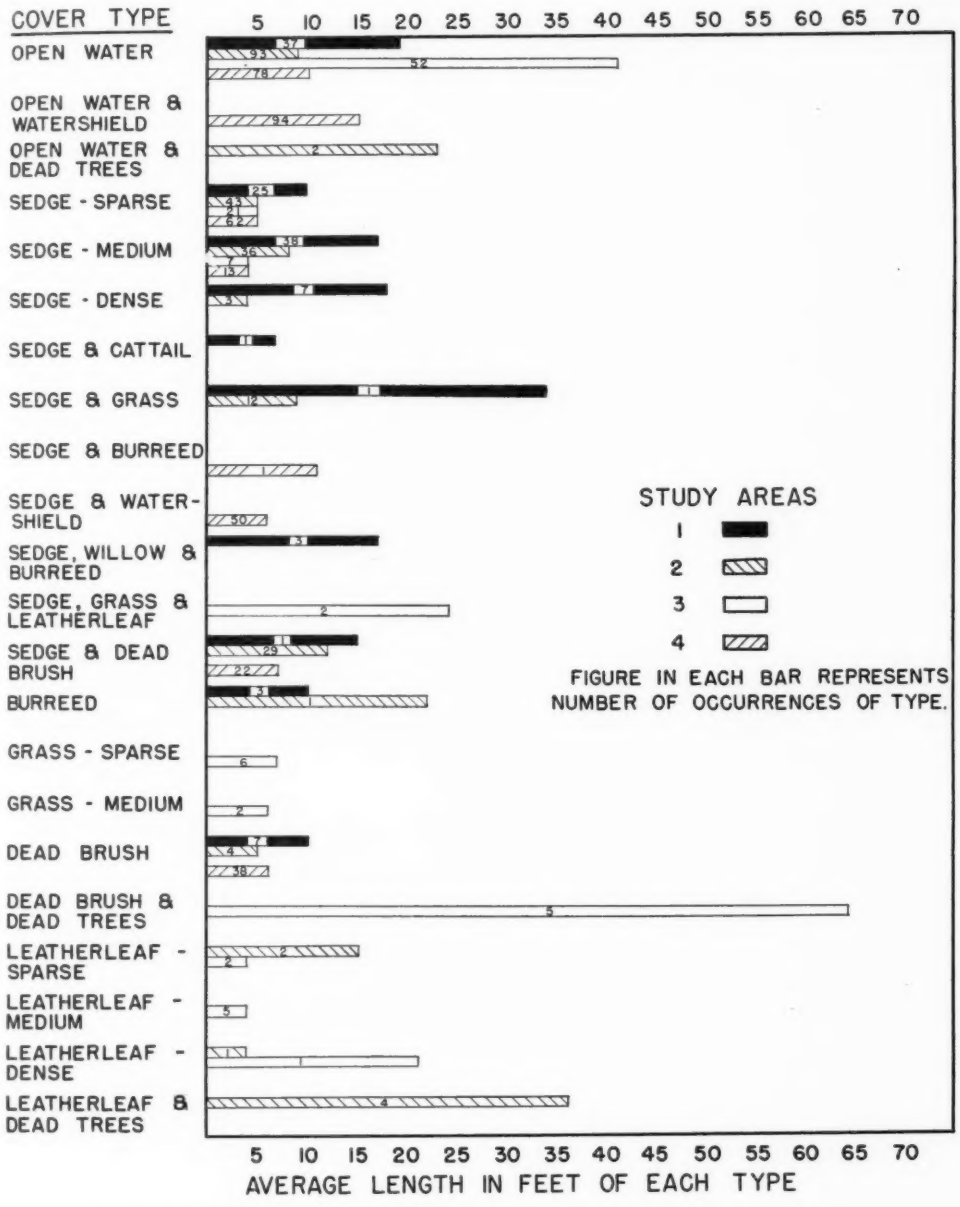

FIG. 2. Interspersion of emergent vegetation and water for the four study areas.

—is obtained by averaging the length of all cover types in the area.

Figure 2 shows that ten environmental cover types were recognized in Study Area I and a total number of 123 type occurrences were tallied. The average size for each type occurrence (based on all occurrences for all types) is 16 feet. The "Index of Interspersion," accordingly, is 12/16′.

These figures take on increased significance when they are considered in relation to the ground and aerial photographs of the area (Figs. 3 and 4). It becomes obvious that 12 as the degree of interspersion and 16′ as the average size for each type occurrence describe a marsh that is well broken up into units of cover and water of usable size for wildlife.

The submerged and floating aquatic vegetation is limited to four species: duckweed (*Lemna minor*), waterweed (*Anacharis canadensis*), bladderwort (*Utricularia* sp.), and fine-leaved pondweed (*Potamogeton pusillus*). These are sparse with puny and spindly growth. Fine-leaved pondweed produced no seed. Of the four species, bladderwort was the most widely distributed, being found in amounts varying from trace to moderate in two-thirds of the 24 sampling stations. Fine-leaved pondweed and waterweed, next in abundance, were recorded at one-third of the stations, in amounts from moderate to common. Duckweed occurred as a trace at five of the checking points. Litter of dead vegetation comprised much of the marsh bottom.

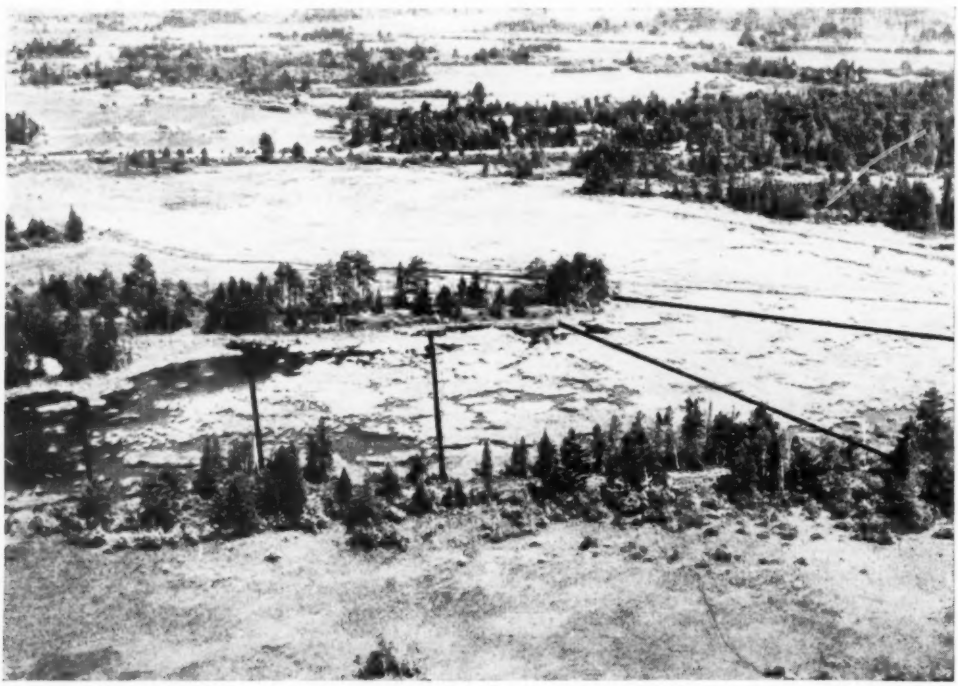

FIG. 3. Study Area I. Ten-acre sedge marsh abandoned by beaver. Lines represent transect lines.

Measurements of the depth of water taken at the 24 stations throughout the marsh showed that the maximum depth was 8 inches and the minimum 3. The greatest depths of 7 or 8 inches were in open water areas at the west end of the marsh and along the ridge on the north boundary. The depth of water in the extensive sedge growth throughout the remainder of much of the marsh varied from 4 to $6\frac{1}{2}$ inches.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9.

Both sweeps were made at each of the 24 sampling stations. Of the aquatics and bottom dwellers small snails (Planorbidae and Physidae), bivalves (Sphaeriidae), dragonfly nymphs (Libellulidae, Corduliidae, and Aeshnidae), mayfly nymphs (Caenidae), backswimmers (Notonectidae), water boatmen (Corixidae), midge larvae (Tendipedidae), water striders (Gerridae), and predacious diving beetle larvae (Dytiscidae) were found in the largest numbers and, in general, had the greatest distribution. In the sweeps on emergent vegetation narrow-winged damselflies (Coenagriidae), chinch bugs (Lygaeidae), plant bugs (Miridae), leafhoppers (Cicadellidae), moths (Lepidoptera), grass flies (Chloropidae), swale flies (Tetanoceridae), and spiders (Araneae) showed up in the highest numbers and at the greatest number of stations. The total number of individuals taken was 140 in the sweeps on the emergents and 391 in the sweeps in the water and on the marsh bottom. This showed there were

FIG. 4. Study Area II. Open water and dead brush zone in the foreground; sedge marsh in the background.

TABLE 9.—SMALL ANIMAL FORMS PRESENT IN THE FOUR STUDY AREAS*

	Area 1	Area 2	Area 3	Area 4	Total
MOLLUSCA					821
GASTROPODA					547
Pulmonata	97	291	87	72	547
PELECYPODA					274
Teleodesmacea	75	27	86	86	274
ARTHROPODA					939
INSECTA					868
Collembola	2	0	0	1	3
Orthoptera	0	5	5	1	11
Odonata	99	48	25	51	223
Ephemerida	12	2	3	1	18
Corrodentia	0	1	0	0	1
Hemiptera	90	32	38	104	264
Homoptera	30	22	10	10	72
Trichoptera	1	1	0	3	5
Lepidoptera	2	1	6	1	10
Diptera	62	50	34	44	190
Coleoptera	10	27	7	11	55
Hymenoptera	2	4	5	5	16
ARACHNOIDEA					71
Araneae	8	19	24	20	71
CHORDATA					39
PISCES					32
Haplomi	1	0	0	0	1
Ostariophysi	0	0	11	20	31
AMPHIBIA					7

* There follows herewith an enumeration of the families represented in the orders as listed above. For the sake of brevity only the total number for all of the four study areas is given. **MOLLUSCA**: GASTROPODA-Pulmonata, Planorbidae 416; Physidae 131; PELECYPODA-Teleodesmacea, Sphaeriidae 274; **ARTHROPODA**: INSECTA-Collembola, Poduridae 3; Orthoptera, Acrididae 6; Tettigonidae 1; Gryllicrididae 4; Odonata, Coenagriidae 53; Libellulidae 89; Aeshnidae 15; Corduliidae 60; Lestidae 5; Gomphidae 1; Ephemerida, Caenidae 15; Baetidae 3; Corrodentia, Psocidae 1; Hemiptera, Notonectidae 12; Corixidae 185; Belostomatidae 7; Nepidae 3; Gerridae 8; Lygaeidae 34; Coreidae 1; Miridae 13; Scutelleridae 1; Homoptera, Fulgoridae 1; Cercopidae 7; Cicadellidae 61; Aphidae 3; Trichoptera, Hydroptilidae 1; Leptoceridae 3; Phryganeidae 1; Lepidoptera, Tineidae 4; Noctuidae 3; Drepanidae 1; Pyromorphidae 2; Diptera, Tipulidae 12; Culicidae 4; Simuliidae 3; Tendipedidae 56; Heleidae 1; Stratiomyidae 4; Tabanidae 2; Otitidae 2; Drosophilidae 2; Chloropidae 64; Tetanoceridae 21; Pipineulidae 1; Dolichopidae 2; Anthomyidae 12; Dixidae 3; Ortalidae 1; Coleoptera, Haliplidae 3; Dytiscidae 11; Hydrophilidae 1; Staphylinidae 1; Coccinellidae 21; Lagriidae 3; Chrysomelidae 12; Lampyridae 1; Gyrinidae 2; Hymenoptera, Tenthredinidae 4; Ichneumonidae 7; Braconidae 4; Formicidae 1; ARACHNOIDEA-Araneae, Argiopidae 55; Drassidae 4; Epeiridae 7; Clubionidae 5; **CHORDATA**: PISCES-Haplomi, Umbridae 1; Ostariophysi, Cyprinidae 27; Ameiuridae 4; AMPHIBIA.

approximately 175 per cent more water and bottom dwellers than terrestrial forms. No pattern of distribution was discernible for any of these insects with reference to any environmental factor, such as depth of water, amount and density of sedge, extent of water, etc.

STUDY AREA II was a river marsh of approximately 6 acres located in the SW1/4 of sec. 21, T. 45 N., R. 13 W. It is just east of the northeast corner of C-1 Pool in Unit 1 of the Refuge.

By spring of 1948 when this marsh first came under intensive observation, an active beaver dam and lodge were present. Well-worn beaver trails leading out of the marsh, up over the dike and down into the adjacent C-1 Pool, suggest that the beaver are forced to leave the marsh and swim considerable distances to obtain food and supplies for dam repairs.

Because of the considerable amount of water in Gray's Creek as well as the rather strong current, the dam is constantly in need of repairs.

There are no distinctive topographical features to mark the northern boundary of this study area, just flooded trees, more marsh and stream. A line parallel to the dike at the south running from the dike on the west to the ridge on the east and crossing the point where the two arms of the creek join and form one stream channel would mark the northern limits of the area. On the east is a wooded ridge. An old road raised above the level of the marsh and a bridge over the creek bound the area on the south. Along the entire western side is C-1 Pool dike.

A moderately heavy patch of dead spruce and jack pine enclosed by the

two branches of the stream stands at the northern edge of the area. Jack pine, spruce, and juneberry grow on the knoll to the east. Along the base of this knoll is a zone of flooded leatherleaf and of dead spruce and jack pine killed when the beaver raised the water level. A few tag alders grow along the road to the south. Along the dike on the west side a fringe of bog birch(*Betula pumila*), spirea (*Spireae salicifolia*), willow (*Salix* spp.), sedges, manna grass, and bluejoint grass grow in moderate abundance.

Two species of sedge are the dominant form of vegetation in this river marsh. The first is *Carex lacustris*, coarse and rough (fittingly known as Ripgut), which grows in tussocks. The second, considerably finer than the former, is *Carex stricta* var. *strictior*. Its stems form beds of the "sedge meadow" type. A third sedge, *Carex lasiocarpa*, occurs only in one small area in the southeast corner of the marsh. Other emergents, namely, bluejoint grass, leatherleaf, and spirea are present in insignificant amounts.

There are three general zones within the marsh. The first and most important is the sedge-brush marsh well broken up by water into a multitude of small units. This environmental type comprises about three-quarters of the entire study area. The second zone is one of open water as represented by the channel of Gray's Creek running through the marsh. It occupies roughly about 15 per cent of the entire area. The third zone is a band of leatherleaf, dead brush and dead trees in various combinations that is found along the east side of the marsh. It constitutes about 10 per cent of the total area.

Within the sedge-brush marsh the ratio of water to emergent cover is slightly less than 1:1. All three degrees of density are found in the sedge vegetation. Dense sedge, however, appears as just a trace; the amount of sparse and medium sedge accounts for almost one-quarter of the entire study area.

Figure 2 reveals that 12 environmental types were recognized in this marsh and a total number of 230 type occurrences recorded. The average size for each type occurrence (based on all occurrences for all types) is 9 feet. The "Index of Interspersion" is, therefore, 19/9′ and is indicative of a marsh that has a multitude of units of cover and water of small size scattered over three-quarters of the study area. Large blocks of any one cover type are lacking with the one exception of the leatherleaf-dead tree zone (Figs. 5 and 6).

Submerged and floating aquatic plants are very poorly represented in this area. There is but one species, bladderwort, found in any appreciable amount. It is distributed throughout the entire marsh in amounts varying from moderate to common. The other two aquatics are water smartweed (*Polygonum natans*) and floating-leaf burreed (*Sparganium fluctuans*), occurring as trace to moderate. Their distribution is restricted to one small section in the southwest corner of the marsh. Litter of dead vegetation is characteristic of the entire marsh bottom.

Measurements of the depth of water were taken at each of the 20 stations spaced along the transect lines. These measurements showed that the deepest water was 34 inches and the shallowest was 9. (This excludes the creek; no measurements were taken of its depth.) The extremes in depth for the interior

of the marsh, *i.e.*, 50 feet or so away from the ridges, dikes, roads and old stream shoulders were 12 inches as the minimum and 34 as the maximum. This gave an average depth of 18 inches for the bulk of the marsh area.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9. Both types of sweep were made at each of the 22 sampling stations. The species of aquatic and bottom dwellers which were found in the largest numbers and which, in addition, had the greatest frequency of occurrence were as follows: snails, bivalves, dragonfly nymphs, water boatmen and midge larvae. Similarly, the commonest species taken by the sweeps on emergent vegetation were short-horned grasshoppers (Acrididae), narrow-winged damselflies, chinch bugs, leafhoppers, crane flies (Tipulidae), grass flies, flies (Anthomyidae), lady beetles (Coccinellidae), leaf beetles (Chrysomelidae), and spiders. The total number of individuals taken was 157 in the sweeps on the emergents and 397 in the sweeps in the water and on the marsh bottom. This shows there were almost 150 per cent more water and bottom dwellers than terrestrial forms—at least during the season of the year (July) when this sampling was done. The distribution of these insects appeared to be random.

STUDY AREA III was a beaver pond of approximately 20 acres. It is located in the NE1/4 of sec. 11, T. 44 N., R.

FIG. 5. Study Area II. Six-acre river marsh flooded by beaver dam. Active beaver lodge at right angle bend in the river and U-shaped beaver dam visible in foreground. Lines represent transect lines.

14 W., and lies about one half mile south of the west side of M Pool in Unit 2 of the Refuge.

In 1947 when this study commenced there were no beaver inhabiting the pond, but the remains of an old broken-down lodge indicated previous beaver occupancy. During that year in an extensive flooding to the south, a very large lodge and an elaborate system of dams were constructed and maintained by beaver.

By 1948 these had been deserted and the old lodge in the study area pond was repaired and reoccupied. Whether this was done by the same beaver that had abandoned the new flooding to the south could not be determined. During this same year, beaver sign was very noticeable on the ridges along the south side of the pond. Felled and partly cut-up "popple" of all sizes were lying about almost everywhere. One knoll bordering the southeast corner was completely denuded of its trees (all poplars). Well-packed trails led from the beaver pond up to the nearby ridges where the food trees grew.

By the spring of 1949 the lodge again had been abandoned, but not completely deserted. The animals transferred their activity to the ridges and marshes bordering the pond on the north, where they dug transportation canals and cut brush and trees heavily. Although no longer living in the pond, they continued to maintain the small mud embankment which effectively dammed the narrow outlet leading out of the pool in the southwest corner.

FIG. 6. Study Area II. Sedge-brush zone well broken up by water into a multitude of small units. Sedge is *Carex lacustris* and ratio of water to emergent vegetation is slightly less than 1:1.

This beaver pond is bounded on the north by a rolling ridge. To the northeast is a low marshy draw through which seepage and natural run-off water enter the pond. These are its chief sources of water. Still farther to the east is a very low sedge-covered ridge which separates the open water from the marsh. It is quite possible that this may be the remains of an ancient beaver dam, but no proof of this was discovered. A sand dike forms the eastern boundary, while along the south side a series of winding knolls successfully impounds the water. A low narrow ridge bounds the pond on the west.

Jack and red pines are well distributed on all the ridges. In addition, spruce is found on the ridge at the western edge of the pool, and some aspen and white birch on the north side ridge. Juneberry and tag alder are present almost everywhere in moderate amounts. Bracken, blueberry, and leatherleaf are the common ground cover. Leatherleaf forms dense beds at the base of some of the ridges. Much of the shoreline zone bordering the open water is characterized by abundant sedges, (*Carex lacustris*, *C. lasiocarpa*, *C. stricta* var. *strictior*), and grasses (manna and bluejoint), with frequent patches of dead trees and brush.

The dominant vegetation in this beaver pond consists of a fine sedge (*Carex lasiocarpa*), manna grass and leatherleaf. Small amounts of cattail, bluejoint grass, and rough sedge (*Carex lacustris*) occur in a few spots. The fine sedge and the manna grass are limited

FIG. 7. Study Area III. Twenty-acre open water beaver pond. Lines represent transect lines.

to the northwest corner of the pond, constituting a sedge-grass marsh equal to approximately 8 per cent of the entire pond area. A second zone is one of dead brush and trees down in the southeast section, comprising about 10 per cent of the pond. The remainder of the beaver pond is open water totaling about three-quarters of the entire area.

In the open water zone there are several small leatherleaf islands with dead spruce or jack pine still arising from them. In the sedge-grass marsh the degree of interspersion is 28. The average length of a sedge or grass unit is 5 feet, while that of a water unit is 11. The grass and most of the sedge are in the sparse classification. There is no dense sedge and only a very small amount of the medium sedge. The ratio of water to emergent cover in this sedge-grass marsh zone is 2:1.

Ten environmental types were set up for the entire beaver pond and a total number of 103 type occurrences recorded. The average length of each type occurrence (based on all occurrences) is 27 feet. The "Index of Interspersion" is, therefore, 10/27′, indicating an area of medium interspersion with units of cover and water of considerable size. The one exception to this is the sedge-marsh zone where the degree of interspersion is high and the average size of each type unit small (Figs. 7, 8, and 9).

With the exception of bladderwort, which was recorded at 14 of the 20 sampling stations, none of the few submerged or floating aquatic plant species

FIG. 8. Study Area III. Open water zone with scattered small leatherleaf islands.

found in this beaver pond were recorded more than three times—an indication of their very restricted distribution. Aquatic plants checked once were duckweed (*Lemna minor*) and water smartweed both as a trace, coontail (*Ceratophyllum demersum*) moderate, duckweed (*Spirodela polyrhiza*) common. Those recorded twice were musk grass (*Chara*) as trace to moderate and water milfoil (*Myriophyllum* sp.) as common. Fine-leaved pondweed was tallied three times in amounts varying from moderate to common. Much of the pond bottom was devoid of aquatic vegetation. It was characterized instead by a barren litter of dead vegetation.

Depth soundings taken at each of the 20 stations spaced along the transect lines showed that the minimum depth was 7 inches and the maximum 37. Around the edges of the pond the water averaged 12 to 15 inches deep, except along part of the south side where it was 7 to 9 inches. At the extreme eastern end of the pond where the water was held by the sand dike, the greatest depths occurred. Here it ranged from 27 to 37 inches. For the remainder of the pond the water varied from 15 to 20 inches. The one exception was in the cove where the mud dam closed the outlet from the pond. Here the water was 27 inches deep.

Table 9 summarizes the results of the insect sweeps made on the emergent vegetation and on the pond bottom. Bottom sample sweeps were made at

FIG. 9. Study Area III. Sedge-grass marsh zone of sparse to medium density. Sedge is *Carex lasiocarpa* and ratio of water to emergent cover is 2:1.

each of the 20 checking stations. Sweeps of insects on emergent vegetation were, of necessity, confined to the 13 stations where emergent growth was present. The forms of aquatic and bottom dwellers found in the largest numbers and usually having the greatest frequency of occurrence as well, were: snails, bivalves, dragonfly nymphs, water boatmen, midge larvae, and minnows (Cyprinidae). Likewise the commonest species taken by the sweeps on emergent vegetation were: cave crickets (Gryllicrididae), narrow-winged damselflies, chinch bugs, leafhoppers, clothes moths (Tineidae), flies (Diptera), midges, grass flies, lady beetles, ichneumon wasps (Ichneumonidae) and orb-weaving spiders (Argiopidae). The total number of individuals taken was 110 in the sweeps on the emergents and 245 in those in the water and on the pond bottom. This indicates that for July, when this sampling was done, there were slightly over 100 per cent more water and bottom dwellers than terrestrial forms. The distribution of these insects appeared to be random.

STUDY AREA IV was a seepage marsh of approximately 20 acres located in the NE1/4 of sec. 30, T. 45 N., R. 13 W. It is just below the dike at the southcentral side of E Pool in Unit 1 of the Refuge.

Although it was not determined when the beaver first moved back into this marsh during the latest reoccupation, they were actively present by the spring of 1948. During the spring and summer of 1949 they were regularly seen or heard.

Two dams are maintained by the beaver. Both are low, built chiefly of mud, and have utilized heavy sedge growth for their buttressing. The longer runs along the east side. It is 2 to 3 inches high and about 250 feet long. There is abundant sign of ancient cutting of poplar saplings that once grew at the dam site. The second dam crosses the depression between the two knolls to the south and thus effectively prevents the water from draining out of the marsh into the large impoundment below. This dam is 9 inches high and about 150 feet long. Here also is ample evidence of alder and poplar once growing on the dam site, but long since cut by beaver. One poplar stump measured 7 inches in diameter. A dam had been in this location for a sufficient time for a zone of sedge growth to become well established on its lower side.

Beaver sign dating from the present reoccupation of the area is not lacking. A great deal of white birch has been cut. One such tree measured 41 inches in circumference at the butt. In another instance an entire clump of six good-sized birch saplings has been felled. In addition, some tag alder, juneberry and one cherry have been cut. All the poplar that grew on the ridges surrounding the marsh was cut long ago. Today, a thorough search reveals not a single poplar growing on any of these ridges about the marsh. The well-worn beaver trails crossing the low dam at the east side of the area into the marsh and large impoundment beyond, indicate that the beaver are travelling some distance to obtain their food and construction materials.

This seepage marsh is bounded on the north by E Pool dike and by a high ridge. On the east a wooded ridge extends southward as a peninsula from E dike and from its tip the low mud

beaver dam continues across the marsh depression to form the boundary. Two high knolls connected by the second beaver dam enclose the area on the south, while a long narrow ridge lies to the west.

Jack and red pines are the dominant trees and grow on all the ridges. In addition, tamarack, white birch, juneberry, and tag alder are found on the knolls on the south and west sides. Blueberry and bracken are the common ground cover. In the peripheral zone bordering the marsh proper, tag alder, willow, and leatherleaf are common in many places, especially at the base of the ridges. Sedges such as *Carex lasiocarpa* and *C. lacustris*, manna grass, bluejoint grass, three-way sedge (*Dulichium arundinaceum*), cattail, soft rush (*Juncus effusus*) are most characteristic of this zone.

The dominant emergent in the marsh consists almost entirely of *Carex lasiocarpa*. It does not form tussocks, but rather its stems form beds of the "sedge meadow" type. Scattered dead willow brush is present in parts of the marsh. Cattail and burreed occur infrequently.

This area consists of two major zones. The first is sedge marsh which accounts for approximately two-thirds of the total acreage. The second is open water comprising the remaining one-third. The open water zone is at the east end of the area. A sparse fringe of dead brush borders it on the west side, *i.e.*, between it and the sedge marsh. In the

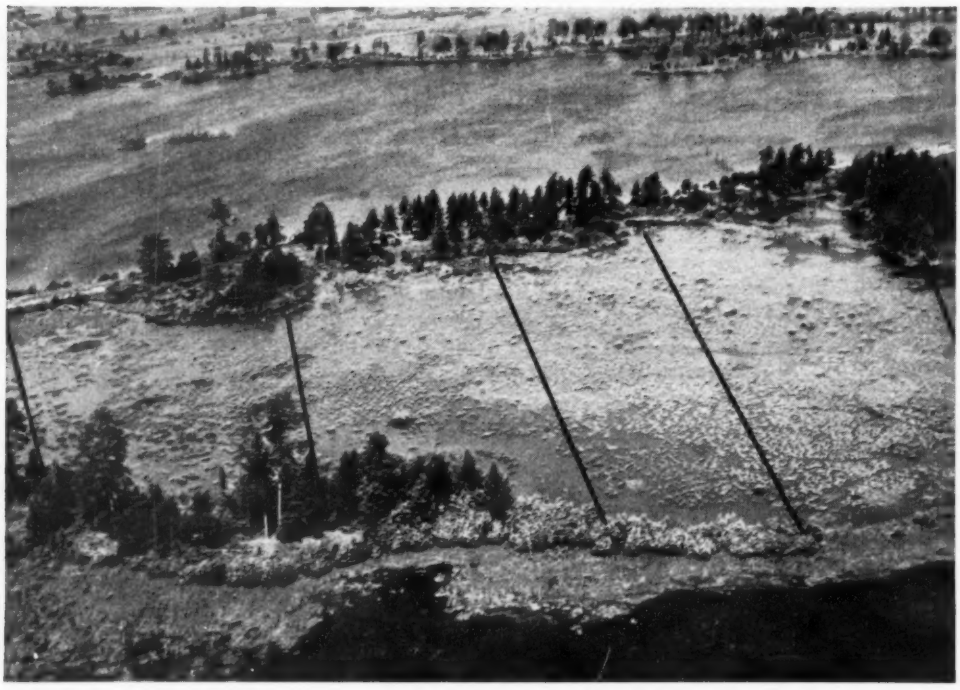

FIG. 10. Study Area IV. Twenty-acre seepage marsh maintained by beaver. Lines represent transect lines.

marsh almost all the sedge falls into the sparse class. There is no dense, and the amount of medium is small. The ratio of water to sedge is almost 2:1.

Eight environmental types were recognized for the area, and there were 358 type occurrences. The average size for each type occurrence (based on all occurrences for all types) is 9 feet. The "Index of Interspersion" is, therefore, 45/9′, indicating a marsh that has an extremely high number of units of cover and water of small size well intermixed. Large solid blocks of any one cover type are lacking, with the one exception of the open water zone (Figs. 10 and 11).

Nine species of submerged or floating aquatic plants were checked at one or more of the 25 sampling stations in this area. Water shield (*Brasenia schreberi*) in amounts varying from common to abundant had the most widespread distribution, occurring at all but four of the checking points. The two next important species were bladderwort, checked at 20 stations in amounts ranging from moderate to common, and waterweed, tallied 17 times as moderate to abundant. Fine-leaved pondweed and yellow water lily (*Nuphar* sp.) were each checked five times in amounts varying from trace to common. The remaining species each recorded at one station were: musk grass (moderate), and floating-leaf pondweed (*Potamogeton natans*) (moderate). Bottom litter of dead vegetation is present in about half the area.

FIG. 11. Study Area IV. Sedge marsh zone of sparse density. Sedge is *Carex lasiocarpa*. *Brasenia schreberi* blankets much of the open water and the ratio of water to sedge is almost 2:1.

Measurements of the depth of water taken at the 25 stations throughout the marsh showed a maximum of 28 inches and a minimum of 10. Water was deepest in the open zone in front of the low mud dam across the depression at the south side of the marsh; the largest area of deep water was at the east side. Here the depths ran from 20 to 23 inches. At the base of the ridge and dike at the north the depth was 10 to 12 inches, while along the ridges to the south it was 13 to 18 inches. For the bulk of the marsh the water depth varied from 14 to 19 inches with an average of 18 inches in most spots.

The results of the insect sweeps made on the emergent vegetation and on the marsh bottom are summarized in Table 9. Bottom sample sweeps were made at each of the 25 station points. Surface sweeps were made at the 15 checking stations where emergent vegetation was present. The species of aquatic and bottom dwellers found in the largest numbers and which, in general, had the greatest frequency of occurrence were: snails, bivalves, narrow-winged damselfly nymphs, dragonfly nymphs, water boatmen, midge larvae, and minnows. Likewise the commonest species taken by the sweeps on emergent vegetation were: narrow-winged damselflies, chinch bugs, plant bugs, leafhoppers, swale flies, grass flies, leaf beetles, and orb-weaving spiders. The total number of individuals taken was 110 in the sweeps on the emergents and 342 in those in the water and on the marsh bottom. At the time when this sampling was done (July) there were 200 per cent more water and bottom dwellers available than terrestrial forms. The distribution of these insects appeared to be random.

ENVIRONMENTAL FACTORS RESPONSIBLE FOR WATERFOWL USE OF STUDY AREAS

When all these physical and ecological characteristics are carefully reviewed and analyzed, six environmental factors are found to be, in general, common to all four areas. These factors are the usual result of beaver flooding in sedge marsh country such as Seney, and it is these same factors which largely explain the strong attraction of the beaver marsh for waterfowl and its intensive use by them.

One of the most important of these factors is the amount of interspersion present in the marshes. The reason for this lies in the habits of the waterfowl themselves. The game species using these areas depend for their safety upon instant access to clumps of emergent vegetation growing in water behind which they can quickly disappear from sight. This cover must be of such density that the ducks can penetrate it easily and without any danger, especially to ducklings, of getting tangled and caught in the dead or matted stems. In other words, it must fall into either the sparse or medium classification as already defined and used in this study. It must also be close enough to water units used by ducks for feeding to provide them with a sense of security.

Since the waterfowl require both units of cover for escape and units of water for a source of food, it follows that the higher the number of these units that an area can provide, the better the interspersion, the greater the number of ducks that can be accommodated and the larger the amount of the area that can be utilized.

A more specific idea of what constitutes good interspersion may be gained from a compilation of some of the measurements made in the study areas. The number of cover and water types varied from 8 to 12 with an average of 10. The number of type occurrences ranged from 103 to 358, and the average length of each type occurrence for each area ran from a minimum of 9 to a maximum of 26 feet. The ratio of water to cover as found in the marsh zones (this excludes large areas of open water) is one of the most significant measurements and most truly indicative of the amount of interspersion present. This ratio did not vary much for the four areas. The highest ratio of water to cover was 2:1 and was present in the sedge marsh portion of the open water beaver pond and in the seepage marsh maintained by beaver. The river marsh flooded by beaver had a ratio of slightly less than 1:1, while the sedge marsh abandoned by beaver had the lowest ratio—1:3. This last ratio is not at all surprising, since with the gradual lowering of the water table due to the disintegration of the beaver dam, the sedge is gradually extending into the water area. The "Index of Interspersion" based on the number of cover type occurrences and on the average size of the cover type units ranged from 45/9′ to 10/27′.

Another common key factor is the composition and juxtaposition of the environmental types. In all four of the areas, zones of sedge marsh, of open water and of dead brush were present. Each fulfilled some requirement in waterfowl needs, for the ducks made use of all of them. The sedge marsh provided security in the form of escape cover, especially for the dabbling ducks; the open water furnished feeding grounds and suitable sites for loafing and preening; the dead brush offered a rich source of insect food especially attractive to ducklings. Repeated observations showed the preference of the ring-necks for open water zones in which to carry on many of their activities. All three of these environmental types seemed to play a fundamental part in the ecology of the waterfowl, and it appeared essential that they be included in any area considered as good waterfowl habitat.

In three of the study areas the sedge marsh zone constituted from two-thirds to three-quarters of the entire area, with the open water and dead brush zones accounting for the remainder. In Study Area III (the open-water beaver pond), however, the proportions were reversed with the sedge marsh occupying 8 per cent, the brush and trees 10 per cent, and the open water 82 per cent of the area. In all four study areas, these three environmental types were contiguous, and the ducks were able to move quickly and easily from one to another. This was important since it enabled dabbling ducks, for instance, to make greater use of the open water zones than would have been possible if the safety of the sedge marsh zone had not been close by and readily attainable.

The third common factor of importance is the depth of water. The dabbling ducks, because of their method of feeding, are restricted to relatively shallow water. Black ducks will make shallow dives when necessary, but even they obtain most of their food by tipping and dabbling. For this reason, water depths of from 6 to 18 inches represent the optimum range for their

feeding. For the ring-necked duck somewhat greater depths of water are desired.

The average depth of water for three of the study areas was 18 inches. It was 5½ inches for the fourth—the sedge marsh abandoned by beaver. The deepest water was in the open-water zones in each of the areas. There the depth averaged from 2 to 3 feet for all the study areas except the sedge marsh abandoned by beaver, where it was 8 inches. It was in these open water zones with their water depths of 2 to 3 feet that ring-necked broods or adults were seen most frequently diving for food.

A fourth factor of vital importance is the amount and kind of animal and vegetable foods present. Both types are required by waterfowl. Ducklings of all species rely almost entirely upon animal foods during the first two or three weeks of their existence. As they grow older, although they utilize an increasingly large amount of vegetable foods, they still consume large quantities of animal food, the amount depending upon the food habits of the individual species.

None of the study areas had a rich and abundant submerged aquatic flora. Very few species were present and, with but one or two exceptions, their growth was sparse and puny. Bladderwort was the one aquatic common to all four areas, being fairly widespread in each area and occurring in amounts varying from moderate to common. It was also the only submerged aquatic in two of the areas. Fine-leaved pondweed and waterweed grew in significant amounts in two of the marshes. The pondweed plants were small and produced no seeds, but manifested a fairly healthy growth. Characteristic of all four of the marshes and ponds was the abundant supply of bottom litter.

In Study Area IV (the seepage marsh maintained by beaver) one species of floating aquatic occurred. This was water shield. Its growth was vigorous, and it covered approximately half of the water surface of the marsh. During July abundant bloom gave promise of a prolific crop of seeds.

In three of the study areas *Carex lasiocarpa* was the dominant emergent plant. In the fourth area, the river marsh flooded by beaver, *Carex lacustris* and *C. stricta* var. *strictior* were the common emergent. Manna grass was also common in the open water beaver pond.

In contrast to the sparsity of good aquatic food plants, the small forms of animal life of the four areas were well diversified and prolific. The following groups were represented by the greatest number of individuals and were the most commonly distributed over all four areas: snails, bi-valves, dragonfly and damselfly nymphs, water boatmen, midge larvae, leafhoppers, grass flies, swale flies, chinch bugs, lady beetles, spiders, and minnows (Table 9).

For all four study areas the aquatic and bottom dwelling animal species outnumbered the more terrestrial forms found on the emergent sedge and brush by a ratio which showed a rather marked uniformity, ranging only from 3:1 to 2:1.

The results of an analysis of the gizzards of 26 ducklings of various ages collected by the writer on the refuge are tabulated in Table 10. These birds, although not shot in any of the study areas, were obtained from habitats of a similar nature. Many of the food items

TABLE 10.—ANALYSIS OF 26 DUCKLING GIZZARDS COLLECTED ON THE SENEY REFUGE[1] (1947, 1948, 1949)

Food item	Composition by Volume (%) Ring-necked duck (11, age 3–8 wks)	Baldpate (3, age 6 wks)	Blue-winged teal (8, age 1–8 wks)	Green-winged teal (1, age 7 wks)	Hooded merganser 2, age 6–7 wks)
Porifera					
Spongillinae	3	..	..	..	..
Bryozoa	tr	..	9	..	..
Mollusca					
Gastropoda	14	..	1	..	..
Pelecypoda	..	..	1	..	..
Annelida					
Hirudinea	..	..	..	tr	..
Arthropoda					
Cladocera	..	..	6	..	..
Cambarus virilis	tr	..	..	..	49
Odonata	32	..	5	..	11
Corixidae	tr	..	1	tr	..
Belostomatidae	..	..	..	..	5
Nepidae	..	..	tr	..	..
Gerridae	..	..	tr	..	..
Trichoptera	28	..	6	..	..
Heterocera	..	..	1	..	..
Chironomidae	..	..	..	75	..
Coleoptera	..	..	tr	..	..
Haliplidae	..	tr	tr	..	..
Dytiscidae	..	..	..	tr	3
Hydrophilidae	..	..	..	..	tr
Chrysomelidae	..	..	tr	..	..
Curculionidae	..	..	..	tr	..
Grinidae	..	3	..	..	..
Formicidae	..	..	tr	..	..
Hydrachnidae	..	..	tr	..	..
Chordata					
Rana sp.	..	..	..	..	32
Sparganiaceae					
Sparganium spp.	tr	..	15	..	..
Najadaceae					
Potamogeton pusillus	18	..	47	tr	..
Potamogeton gramineus	..	..	tr	..	..
Potamogeton pectinatus	..	..	tr	..	..
Hydrocharitaceae					
Anacharis canadensis	4	97	1	..	..
Gramineae					
Glyceria canadensis	..	..	..	25	..
Cyperaceae					
Eleocharis palustris	tr	..	tr	..	..
Rhyncospora fusca	1	..	..	..	..
Cladium mariscoides	tr	..	..	..	..
Carex (lasiocarpa & stricta)	tr	..	4	tr	..
Polygonaceae					
Polygonum amphibium	..	..	1	..	..
Rosaceae					
Potentilla sp.	..	..	tr	..	..
Rubus sp.	tr	..	..	..	..
Prunus virginiana	..	..	1	..	..
Ericaceae					
Gaylussacia baccata	..	..	1	..	..

[1] Stomach analyses made by F. M. Uhler and data released through courtesy of the Fish and Wildlife Service.

found most frequently are the same as those commonly present in the four study marshes.

Studies by Martin and Uhler (1939), Cottam (1939), McAtee (1918, 1939), and Mabbott (1920), likewise, showed many of the plants and small animal forms most characteristic of the study areas to be utilized by adult ducks for food in varying degrees.

A fifth factor of considerable importance is the degree of freedom from human disturbance that is possessed by the marsh or pond area. Ducks, especially during the rearing period and during the flightless stage in the postnuptial moult, will not tolerate much disturbance by people. If such persists, they will desert the area. (Beard, 1947).

Under ordinary circumstances, each of the four study areas possesses the necessary seclusion either through being located sufficiently far from the main traveled dikes, or by the existence of a screening strip of woods between it and the dike road. If any of these areas, however, should fall within a zone opened to the public for recreational use, such as fishing, their use by waterfowl will sharply decrease, as was the case in 1947 when Study Area IV was included within the area open to fishing. During that year only two broods and 70 adult ducks were seen. In the two years that followed, however, when this marsh was closed to fishing, a marked increase in both broods and adults was noticed (Tables 7 and 8).

A sixth and final major factor is the availability of suitable nesting cover within a reasonable distance from the brood-rearing marsh. There is no shortage of this type cover for any of the four study areas. For the black and mallard there are plenty of low-growing jack pine and red pine, blueberry bushes and dead brush piles; for the baldpate and blue-winged teal an almost limitless amount of dry sedge marshes; for the wood duck and hooded merganser numbers of suitable dead trees.

In summary, six environmental factors have been found common to the four areas under study. The critical analysis of the areas showed them to be key characteristics and the ones which explain in a large measure the attraction of these habitats to waterfowl. These factors are: proper interspersion of cover and water; composition of environment to include units of marsh, open water, and dead brush; suitable depth of water; adequate supply of vegetable and animal food; freedom from human disturbance; and suitable nearby nesting cover. Marshes and ponds possessing these six factors have gone a long ways toward fulfilling waterfowl requirements for optimum habitat.

Proof of this is reflected in the duckling production figures for the study area as shown in Table 11.

The average number of young produced each year per acre ranged from 1.7 to 4.6. Even the lowest average yield of ducklings (1.7) is more than 1.5 ducks per acre—and that, considering both the nature of the environment and the nesting habits of the species of ducks using these areas, is productivity of a high order.

There is a clear correlation between duckling output and "Index of Interspersion." Those areas with the most favorable "Index of Interspersion" lead almost without exception in the number of ducklings produced each year. Although this index is not a measure of

TABLE 11.—DUCKLING PRODUCTION FOR THE FOUR STUDY AREAS

Area	No. acres	Total no. ducklings in 1947	Total no. ducklings in 1948	Total no. ducklings in 1949	Total no. ducklings for 3 yrs.	Av. no. ducklings per year	Av. no. ducklings per year per acre	"Index of Interspersion"
Study Area I.....	10	71	24	13	108	36	3.6	12/16′
Study Area II.....	6	..	28	28	56*	28	4.6	19/9′
Study Area III.....	20	52	25	25	102	34	1.7	10/27′
Study Area IV.....	20	10	46	68	124	41	2.1	45/9′

* Production for two years only (1948 and 1949).

all the six key factors, it is for the important ones relating to amount, composition and juxtaposition of cover and water.

Study Area IV has the highest "Interspersion Index" (45/9′); likewise it has led in duckling production in 1948 and 1949 by a substantial number. In contrast its 1947 output was very low. This is explained by the fact that during that year it was included within the open-to-fishing zone, and because of the constant disturbance from fishermen, was virtually abandoned as a duckling-rearing marsh.

Study Area II has the second most favorable "Interspersion Index." For the two years this area was studied, the number of ducklings produced likewise ranked second.

Study Areas I and III show little significant difference in their "Index of Interspersion." Likewise the total number of ducklings produced by each of these two areas is very similar. Duckling output for the sedge marsh abandoned by beaver (Study Area I) has steadily declined during the three-year study period. This is probably largely accounted for by the decreasing water levels and corresponding encroachment of solid sedge growth occurring as the result of the abandonment of the area by beaver.

USE OF STUDY AREAS BY OTHER WILDLIFE

Other forms of wildlife besides waterfowl were not slow to respond to the very favorable types of marsh and aquatic habitat created by the beaver. They were observed in varying numbers in all the areas under study. A list of such animals would include deer, otter, mink, muskrat, and marsh birds, such as the great blue heron, pied-billed grebe, and Canada goose.

Their effect upon the ducks using the areas was not easy to ascertain. In most instances it is probable that they existed together in these marsh environments without conflict or harmful influence. For example, deer were frequently observed standing knee deep in the marsh pulling up and eating great quantities of submerged aquatics, such as bushy pondweed, fine-leaved pondweed, and waterweed. The first two plant species listed are among the preferred food plants of ducks, but there was no competition in view of the size of the area, the amount of aquatic plant growth, and the number of deer.

If muskrats in these beaver-created marshes exercised any influence at all upon the waterfowl, it was generally a beneficial one. In Study Area IV there were three muskrat houses, and musk-

rats were frequently seen swimming about. Their use of cattail and some sedge for food and construction material would be valuable in helping to thin these emergents and in creating the openings in the marsh vegetation, so well-liked by ducks, if the emergents ever began to grow too densely. This condition, however, did not exist in any of the four areas under study. Muskrat houses were favored by ducks for preening and loafing, and also supplied potential nesting sites.

A few mink were seen in the four beaver marshes or ponds. Three were trapped in November, 1949, in Study Area IV. Their prey includes both adult and young ducks. It is reasonable to assume that their presence is detrimental to waterfowl production.

Observations of otter in the study areas were made on three occasions. In September one was watched swimming and rolling in Study Area III. Two others were seen in Study Area II. Too little is known about the habits of the otter to judge whether its presence has any effect upon the waterfowl found in the same area.

Canada geese were frequently observed in all these areas, but no evidence of any conflict between them and the ducks was ever detected. In Study Area IV one Canada goose nested and successfully hatched six goslings. All the areas were used at various times by the geese for rearing their broods and by adult geese for feeding and loafing.

Marsh birds, such as the pied-billed grebe and the great blue heron, were common in the beaver pond environments. That conflict sometimes existed between the pied-billed grebe and the ducks was suggested by two observations made in Study Area IV. On May 27 two black ducks flew into the marsh and began feeding. Almost immediately a pied-billed grebe began to harass them. It rushed along the surface of the water in short spurts toward the ducks, forcing them to fly ahead a few feet. This was repeated several times. This behavior was repeated on one black duck in the same part of the marsh on June 9. Whether the grebe was defending a nest site from too close approach by the ducks is not known. The ducks certainly showed no aggressiveness, but yielded completely to the belligerence of the grebe.

The great blue heron is an integral part of these marsh and aquatic habitats. Nothing was observed to indicate that it had any influence either harmful or beneficial upon the waterfowl in the area. It is strongly suspected that very young ducklings might on occasion be killed by these herons.

MANAGEMENT RECOMMENDATIONS FOR BEAVER-WATERFOWL HABITAT

One of the major objectives in waterfowl management is to maintain and to increase suitable environment.

There are several management measures applicable. All of them either directly or indirectly relate to the beaver. Since the ponds and marshes created by the beaver under natural conditions, such as are found at the Seney Refuge, fulfill waterfowl requirements so well, it is but logical to use the beaver as one means of achieving this objective. Management efforts, therefore, should be directed toward maintaining the beaver population at the highest possible level consistent with creation and maintenance of optimum waterfowl habitat.

This means that beaver numbers must not be allowed to outstrip their available food supply. Enough beavers must be removed periodically to keep the population in balance with the growing capacity of their food trees.

The desired objective in managing beaver in areas where the interests of the waterfowl have first priority is to promote and safeguard the continuous occupation and maintenance of ponds. Such achievement depends on a trapping program which will remove enough beaver so that food needs of those remaining in the colony will not exceed the annual replacement growth of the available food trees.

Several danger signs appear when the beaver are getting out of balance with their food supply. The disappearance of poplar within several hundred yards of the lodge, heavy feeding on white birch, construction of lodges in obviously unfavorable sites, and abandonment of ponds, are examples of such warnings.

The number of beaver which can be safely removed without jeopardizing the breeding stock according to Bradt (1947) is approximately one-third of the total population. He explains: "Since a theoretical loss of 50 per cent per year would be the maximum possible without reducing the total population, and a loss of 25 per cent per year should allow a steady increase, perhaps a 33-1/3 per cent loss, or approximately one-third of the total, should be satisfactory to maintain the population, or even to permit a slow increase."

Swank (1949) figures that the annual increase in beaver is one-third of the population and that this increase may be harvested annually and still allow "a margin of safety to offset any possible unforseen circumstances that may drastically reduce the population."

The second major recommendation calls for the maintenance and repair of suitable abandoned beaver ponds wherever feasible. The job can be done simply, effectively and cheaply by the use of simple materials that are adequate to insure as great a permanence to the structure as is needed. The repair or replacement of the dam is, in most cases, a minor one, since beaver dams built in this type environment are usually not very long or high.

This second recommendation was carried out in one place on the Seney Refuge in September, 1948 under the direction of Refuge Manager C. S. Johnson. The area was a seepage marsh characterized by much sedge, leatherleaf and bordering zone of dead spruce. In 1945, it could be easily traversed by duck boat. A small dam, that plugged the road culvert and thus impounded water, and a lodge were actively maintained by beaver. By 1947 the beaver had deserted the area. The lodge and dam had disintegrated, the marsh was completely drained and sedges were beginning to invade the mud bottom. At the cost of approximately $50 for labor and materials a simple structure of board piling and wood sill, earth and rock fill was constructed across the small outlet drain (Fig. 12). This was all that was needed to stop the run-off and restore the necessary amount of water to enable the marsh again to function effectively as duck-rearing habitat (Fig. 13).

The record of waterfowl use of this small marsh during the one season (1949) since its restoration is: 46 blacks, 6 ring-necks, 6 wood ducks, 6 baldpates, 5 mallards, 4 blue-winged teal, 2 green-

winged teal, 2 hooded mergansers and one shoveller—a total of 78 ducks. Its duckling production is equally impressive. Five broods were recorded: two of wood duck and one each of black, ring-necked and hooded merganser. The number of ducklings was 13.

The immediate response to a restored beaver marsh area indicates the value and inherent possibilities in this second management recommendation. If the simple method of construction as outlined above is followed, the cost will be small. In terms of benefit to wildlife the potential value is great.

The construction of man-made "beaver ponds" is suggested as a third management measure. This recommendation is based upon the idea of imitating the beaver ponds—of creating by artificial means the same environmental conditions as those produced by the beaver in his own impoundments. A simple structure of wood plank piling, wood sill boards, and earth fill would be practical and effective when the right combination of low area, surrounding ridges and source of water occurred. In the Seney marsh area numerous places were observed where the construction of a low simple wooden dam across a low area between two ridges, for example, would be sufficient to impound successfully the seepage or run-off water and convert a profitless marsh area into a pond capable of producing ducks.

This recommendation was carried out in one favorable spot in the Seney Ref-

FIG. 12. A simple structure of piling, woodsill, earth and rock fill constructed across a small outlet drain and later reinforced by materials brought in by beaver was sufficient to stop run-off and rehabilitate the marsh.

uge in September, 1948. The spot chosen was a small bay at the western end of B Pool which had long been separated from the main body of the pool by a very ancient beaver dam. This dam was so old that good-sized birch trees and alder bushes had become well established on it, and its original function as a dam had long since disappeared. In the course of time a break-through in the dam deepened into a channel about 12 inches wide connecting the two bodies of water. Usually by the end of July the water in the small bay had all run out or evaporated. Wood spill boards and sill were built across the channel. Wooden piling and aprons anchored the structure to the ancient dam. Earth and rock fill buttressed the piling. Now, as a result of simple inexpensive construction, the amount of water in the bay can be regulated and a "beaver pond" has been built potentially capable of producing ducks.

It is recommended as a fourth management measure that, wherever feasible, water be diverted to suitable dry marsh areas and the beaver be relied upon to carry on from there. This suggestion proposes to follow the pattern established by streams when siltation forced overflowing of banks, spreading over the surrounding area, and cutting a channel elsewhere. As a result, the marsh is flooded and opened up and much brush killed. Areas suitable for such treatment should have sufficient fall in elevation to allow the water to wander through the marshes seeking its own level and proper spacing along

FIG. 13. A sedge marsh reflooded and restored to the production of waterfowl as the result of the construction of a simple wooden spill dam.

natural contours of enough ridges and knolls to permit the construction of occasional small retaining dikes designed to create storage pools to ensure a permanent supply of water. With the presence of this water, and provided the ridges furnished an adequate supply of food trees, it is very probable that the beaver would move in and commence building ponds. The results of such a program contributed to by both man and beaver would be a chain of marshes, small ponds, and connecting flowages to provide the type of habitat essential for dabbling ducks of the lake states. In addition, it is simple, relatively inexpensive (when compared to the cost of building major impoundments), and, in harmony with the needs and nature both of the marshes and of the waterfowl.

CONCLUSION

Waterfowl habitat requirements in marsh country, such as exists at the Seney Refuge, are well met in the marshes and ponds constructed by the beaver. This animal, quick to respond to the presence of water, moves into suitable areas and in the course of producing an environment suitable for his own needs, at the same time unwittingly creates ideal waterfowl habitat.

Wise planning on the part of waterfowl managers will take advantage of this trait and utilize it to the fullest extent. Wherever feasible, management should lend a hand and divert water into dry areas otherwise suitable, so that beavers can move in and commence a low-cost program of waterfowl marsh building. Management, also, should carefully study the composition of these beaver marshes and ponds and imitate them as closely as possible in its own plans for waterfowl habitat improvement. It should be recognized that although big bodies of water impounded by long dikes serve a useful purpose, these alone are not sufficient to satisfy duck habitat requirements. They do not fulfill the needs of dabbling ducks for much of their feeding or for brood-rearing and moulting cover.

The beaver aids the manager in s another way. When break-throughs in ditch banks occur, it is not at all unusual to find that the beaver within a short time has built a dam across the break and done it so effectively that further repairs are unnecessary. In one of the main diversion ditches in the Seney Refuge there are no less than three major break-throughs, all of which are effectively repaired by beaver dams (Fig. 14). The largest of these dams is 30 feet long and $2\frac{1}{2}$ feet high.

The relation of beaver to waterfowl in environments similar to those existing in the Seney marshes is close and important. Successful waterfowl management will profit both by the actual work done by the beaver and by the example set. The cost is low. The value received in terms of duckling production is great. Acre for acre, it is the "beaver" marshes—either beaver-made or man-made—that attain truly high productivity.

SUMMARY

Field work to study the habitat preferences of waterfowl, and, in particular, the role of the beaver as the creator of these habitats was carried on by the writer during the spring and summer months of 1947–1949 at the Seney National Wildlife Refuge in Michigan.

Four areas typical of refuge marsh

habitat and embodying different stages in beaver activity were selected for detailed study.

The objectives of the study were three-fold: (1) to keep these study areas under intensive surveillance in order to determine the extent and purposes of their use by waterfowl; (2) to analyze the physical characteristics of the areas in order to determine the important factors responsible for their attraction to waterfowl; (3) to determine practical management measures designed to maintain and to establish a maximum number of such beaver ponds and marshes.

The results of the field observations of waterfowl activities in these marshes and ponds during the three years showed that they were receiving heavy use and were fulfilling several functions of vital importance to the birds. They were serving as a place where courtship was carried on and where territories were established by mated pairs; they were providing food and cover suitable for rearing broods; they were furnishing food and cover for migrants in the spring as well as for an additional influx of ducks in the late summer; and finally, they were providing the isolation, food, and escape cover required by dabbling ducks during the flightless period of their post-nuptial moult.

The detailed analysis of the physical and ecological characteristics of the four study areas when carefully reviewed and analyzed, showed that certain factors were, in general, common to all four areas. These factors appear to be the usual result of beaver flooding in sedge marsh country such as Seney, and it is these same factors which largely explain

FIG. 14. Break-through in one of the main refuge diversion ditches effectively repaired by beaver.

the strong attraction of the beaver marsh for waterfowl and its intensive use by them.

The first of these factors was the amount of interspersion of cover and water present. In order to express interspersion numerically, the total number of occurrences in a specified unit was divided by the number of cover types present in the same unit. The resulting figure was the numerator in the "Index of Interspersion." This figure ranged from 45 to 10. The number of cover and water types varied from 8 to 12 with an average of 10. Since the size of a unit of environmental type conditions to a considerable extent its potential use, the average size of the cover type units was included in the measurement of the interspersion and expressed as the denominator in the "Index of Interspersion." This figure was obtained by averaging all occurrences of all cover types in the same area used to measure the degree of interspersion as expressed in the numerator of the index. The average length of each type occurrence for each area ran from a minimum of 9 to a maximum of 26 feet.

A second key factor was the composition and juxtaposition of the environmental types. In all four of the areas, zones of sedge marsh, of open water and of dead brush were present. In three of the study marshes, the sedge marsh zone constituted from two-thirds to three-quarters of the entire area, with the open water and dead brush zones accounting for the remainder. In the fourth study area, these proportions were reversed. These three environmental types were contiguous which enabled the ducks to move easily and quickly from one type to another.

The third factor of importance was the depth of water. The average depth of water for three of the study marshes was 18 inches; for the fourth it was $5\frac{1}{2}$ inches. The deepest water was found in the open water zones in each of the areas. There it averaged from 2 to 3 feet for all the study areas but one where it was 8 inches.

A fourth factor of vital importance is the amount and kind of animal and vegetable foods present in the marshes. Both types are required by waterfowl. None of the study areas had a rich and abundant submerged aquatic flora. Very few species were present and with but one or two exceptions, their growth was sparse and puny. Bladderwort was the one aquatic common to all four areas, as was an abundant supply of bottom litter.

In contrast to the sparsity of good aquatic food plants, the small animal life as indicated by sampling of the four areas was well diversified and prolific. The following groups were represented by greatest number of individuals and were the most commonly distributed: snails, bi-valves, dragonfly and damselfly nymphs, water boatmen, midge larvae, leafhoppers, grass flies, chinch bugs, lady beetles, and spiders. The aquatic and bottom-dwelling animal species outnumbered the more terrestrial forms found on the emergent sedge and brush by a ratio which showed a rather marked uniformity, ranging only from 3:1 to 2:1.

Reference to the results of an analysis of the gizzards of 26 ducklings collected on the refuge and to other food habit studies showed that many of the more important animal and plant species present in the study areas were among

the foods commonly consumed by ducks.

The possession of sufficient isolation to guard against disturbance from people was the fifth factor common to all four study areas.

A sixth and final factor of major significance was the availability of suitable nesting cover within a reasonable distance from the brood-rearing marsh. There was no shortage of this type cover for any of the four study areas.

Marshes and ponds possessing these six factors go far toward fulfilling requirements for ideal waterfowl habitat, reflected in the duckling production on the study areas. The average number of young produced each year per acre ranged from 1.7 to 4.6. Considering the nature of the environment and the nesting habits of the species of ducks using these areas, this is productivity of a high order.

There is a clear correlation between duckling output and "Index of Interspersion." Those areas with the most favorable "Index of Interspersion" lead almost without exception in the number of ducklings annually produced. Although not applicable to all the six key factors, this index is a measure for the important ones relating to amount, composition and juxtaposition of cover and water.

Other forms of wildlife respond to the very favorable types of marsh and aquatic habitats created by the beaver. A list of such animals would include deer, otter, mink, muskrat, and marsh birds, such as the great blue heron, pied-billed grebe, and Canada goose. Field observation suggested that in most instances, it is probable that they existed together in these marsh environments without conflict or harmful influence. The mink was the one important exception to this.

Several management measures were suggested as a means of maintaining and increasing to the greatest extent possible the amount of environment suitable for ducks. The first is directed toward maintaining the beaver population at the highest possible level consistent with its function of creating optimum waterfowl habitat. It suggests that careful and efficient trapping be done to keep the beaver in balance with the available supply of its food trees, so that it would not be forced to desert its ponds and dams, which, when thus abandoned, soon disintegrate.

The second major recommendation calls for the maintenance and repair at reasonable expense of suitable abandoned beaver ponds wherever feasible. The immediate response to such a restored beaver marsh indicates the value of this suggested measure.

Pond construction is suggested as a third management measure. This recommendation is based upon the idea of imitating the beaver ponds—of creating by artificial means the same environmental conditions as those produced by the beaver in its own impoundments. It calls for the use of low simple wooden dams in locations where the right combination of low area, surrounding ridges and source of water occur.

The fourth management measure recommends that wherever feasible, water be diverted to suitable dry marsh areas and the beaver be relied upon to carry on from there.

Successful waterfowl management will take advantage of the beavers' ability as a creator of ideal waterfowl habitat and will utilize it to the fullest extent.

It will recognize that although big bodies of water impounded by long dikes serve a necessary and useful purpose, they alone are not sufficient to satisfy duck habitat requirements. It will realize that the beaver has set the pattern of optimum waterfowl environment. Management will be wise to copy it.

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THE CALL-COUNT AS A CENSUS METHOD FOR BREEDING MOURNING DOVES IN GEORGIA [1]

Terry A. McGowan

Dept. of Fish & Wildlife Resources, Frankfort, Kentucky

Wildlife biologists are in general agreement that mourning dove population density declined between 1940 and 1950, with an especially alarming reduction occurring in 1950 following severe local outbreaks of trichomoniasis and adverse weather conditions in parts of the winter range (Haugen, 1952; Stabler and Herman, 1951; Foote, Moore, and Peters, 1951). While the causes and extent of the decline are debatable, there is general agreement that management measures must be applied if the dove is to regain a high enough population level to remain on the game list in the southeast. A practical census method, one that is reliable yet suitable for wide use without excessive expenditure of time and money, is essential to management. The "call-count" method has been considered the most promising for measuring relative abundance of breeding doves. This method was first developed and used by McClure (1939), but only in the past three years has it been considered for large-scale use throughout eastern North America. This paper is a report on a two-year intensive study of the call-count as a method for censusing doves on the Georgia piedmont. A preliminary report on the first year's data has appeared in the Special Scientific Reports of the Fish and Wildlife Service (McGowan, 1952). The study was conducted concurrently with a two-year investigation by Hopkins and Odum (1953) of the spot-mapping census method which is designed to measure density on a per-area basis (i.e., space-relative density as contrasted with time-relative density measured by the call-count).

This study was suggested by Harold Peters of the Fish and Wildlife Service and Leonard E. Foote of the Wildlife Management Institute; it was directed by Dr. Eugene P. Odum of the University of Georgia. Financial aid and transportation were supplied by the Wildlife Conservation Project of the University of Georgia from funds provided by the Georgia Game and Fish Commission.

Procedures

In March, 1951, an experimental 20-mile route, which has now become standardized in the cooperative Dove Investigation (Foote, 1951), was mapped in Oconee County, Georgia. The route formed a nearly closed circle on secondary roads and had 20 observation stations, located approximately one mile apart (see map, McGowan, 1952). Only one of the stations was situated on a paved road. The route crossed no large stream but passed through typical upland, piedmont farmlands. Small grains,

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cotton and corn fields, abandoned fields, pastures, pine, and mixed pine-hardwood woodlands were typical of the area. Average altitude was approximately 700 feet above sea level.

A count required approximately two hours, with three-minute stops at each station, and three minutes of driving time between stations. Number of doves calling and total number of calls (one call usually consists of four notes or coos) as well as number of doves seen at and between stations, were recorded for each of the 20 stations.

Between March 8 and September 24, 1951, 37 morning and 37 afternoon counts were made by one observer (the author, except for several counts early and late in the season) beginning at Station One. In 1952, 15 morning and 15 afternoon counts were made by the author over the same route between March 26 and July 15. Counts were not made in rainy weather or when wind velocity was greater than Beaufort 3 (8–12 m.p.h.). Morning counts always began exactly one-half hour before official sunrise and afternoon counts two hours before sunset. Weather permitting, morning and afternoon counts were consecutive, either on the same day, or afternoon of one day and morning of the next. In addition to these one-man counts, a five-crew count was made during one morning and one afternoon of each month, March through August in 1951 and April through June, 1952. On these counts one or more observers started in a vehicle simultaneously at Stations 1, 5, 9, 13, and 17, and continued clockwise around the circuit to their respective starting point. Experienced observers participated in the five-crew counts, which made it possible to determine changes in calling levels during the two-hour census period and to evaluate calling activity at each station independent of the time factor.

In May 1952, five 100-acre study areas were set up at Stations 2, 5, 9, 16, and 20. These 100-acre plots were so arranged that call-count stations were located near the center of the respective plots. On each of these five areas the forest edge was cruised on three different days and actual breeding population estimated by the spot-mapping method of Hopkins and Odum (1953). The purpose of this portion of the study was to determine the correlation, if any, between level of calling, nesting activity, and breeding population density. Data on one additional 100-acre plot at Station 10, spot-mapped in 1951, were also available.

RESULTS

Results are summarized in Figures 1–3 and in Table 1. Details (including number of doves heard and seen, number of calls, weather, etc.) of 104 one-man and 16 five-crew counts are included in tables in the original thesis deposited in the University of Georgia Library.

ONE-MAN COUNTS. Total number of doves heard on each of the 37 morning and 37 afternoon 1951 counts, and on each of the 15 morning and 15 afternoon 1952 counts are plotted (as moving averages of three) in Figure 1. The smoothed curve shows that morning calling activity in 1951 remained at a low level in March and early April, increased abruptly in late April, and reached a rather consistent plateau between May 15 and June 15. A gradual but persistent decline occurred after

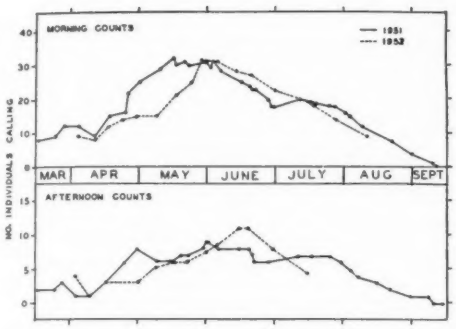

FIG. 1. Morning and afternoon call counts for 1951 and 1952 plotted as moving averages of three.

June 15. The 1952 morning counts show the same low level of calling activity in March and early April, but the peak was not reached until near the end of May. Thus, in both years there was what might be termed a "peak-season plateau" of approximately a month's duration with a tendency for highest counts to occur at the beginning of the plateau. However, this plateau was reached fully two weeks later in 1952 than in 1951. There were no very marked differences in average temperature and rainfall values for the two seasons, although the last half of April was cooler (60.7° mean as compared with 64.3° F) and drier in 1952 and this may have been responsible for the delay in the peak season. It was very noticeable that in 1951 the first pronounced increase in calling in April occurred when early morning temperatures increased from 40–45° to 60–65° F.

Smoothed curves of afternoon counts (Fig. 1) were similar for both years. Afternoon counts were approximately one-third as high as morning counts, but showed approximately the same seasonal trends with, however, a tendency for a longer plateau period, at least in 1951. Afternoon counts were definitely more variable than morning counts. Thus, the coefficient of variation of morning counts between May 10 and June 15 (peak season), 1951 was 12.6 and for afternoon counts during the same period, 26.6. Likewise, the coefficient of variation of morning counts between May 22 and June 20 (peak

TABLE 1.

Column No.	1	2	3	4
			Average no. doves per station visit on call-counts	
Station	Breeding pairs of doves on 100 acres	Breeding pairs on 100 acres plus buffer	Av. at time of census	Av. for entire season
2	2	3	1.28	1.00
5	1	2	1.47	1.57
9	2	3	2.00	1.50
10 *	4	4	2.60	1.92
16	2	2	0.50	0.57
20	0	0	0.50	0.35
Average	1.8	2.3	1.39	1.15

* 1951; all others 1952.

season), 1952 was 5.9 and for afternoon counts during the same period, 30.

The average number of birds heard per 20-station count during the morning at peak season was 30.6 in 1951 and 28 in 1952, the difference being 2.6 ± 1.43. Since the standard error of the difference is large, the difference cannot be considered significant. Thus, the two years differed in the timing of the season, but apparently not in the average calling population density on the route as a whole.

Counts were quite consistent when made at two or three day intervals in good weather. Wind proved to be a very important factor; as already indicated, counts were not made in strong wind, but even at Beaufort 2–3, the number of doves heard was lower, especially early in the season. Wind apparently reduced calling activity and also made it more difficult for the observer to hear the calls. In 1951 the average number of individual calls (a call being 4 or less notes at a single utterance) per dove, heard at three-minute stops, increased from 3.8 in March and early April to 6.2 during the peak of the season. Corresponding figures for 1952, when fewer counts were made, were 4.5 and 5.0.

Number of birds seen during the two-hour count varied much more than the number heard. It has been shown that roadside counts of doves seen are of little value unless the total miles covered is very large (Nelson, 1951). Obviously, a 20-mile route is an entirely inadequate sample. However, the number of birds seen showed peaks in late April and late June in both years, and in August in 1951. It is possible that these peaks represent the appearance of juveniles or perhaps definite migratory movements.

As discussed below, there was no evidence that the adult breeding population shifted to any extent between April and July.

FIVE-CREW COUNTS. To determine variation in calling activity during the two-hour period, number of doves heard at the first four stations visited by each of the five crews (which began simultaneously at Stations 1, 5, 9, 13, and 17) was totalled. This figure represents the number of doves heard at all 20 stations during the first fifth of the two-hour count; i.e., each of the 20 stations was visited once by some one of the crews during the first 24 minutes of the count. Similarly, the number of doves calling at the next four stations visited by each of the five crews was totalled, and so on. Five totals, which represent average calling activity over the entire route at successive intervals during the two hours, were thus obtained. These totals for both morning and afternoon are plotted in Figure 2, using an arbitrary 30-minute

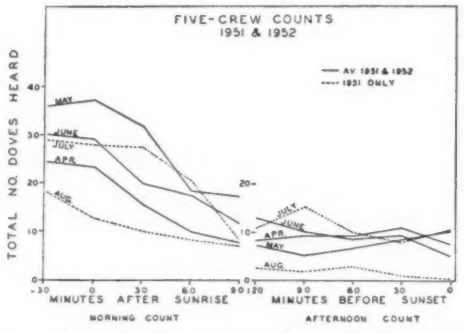

FIG. 2. Calling activity during the 2-hour period of the count as determined by 5-crew count data. Note decrease in calling activity during the second hour of the morning counts.

interval. The over-all trend of these data representing 8 morning and 8 afternoon five-crew counts in both years was very

consistent. Calling activity was very definitely less during the second hour (or 30 minutes after sunrise) in the morning as compared with the first hour. In the afternoon, however, calling did not consistently increase or decrease during the two-hour period before sunset. This means that during a morning count by one man or crew, the last half or so of the route will be subject to a time bias; results obtained at the last stations will not be strictly comparable with results obtained at stations visited during the first hour. In other words, fewer doves will likely be heard at the end of the route even if the calling population is the same as at the beginning.

Utilizing the 5-crew count data to eliminate time bias, each of the 20 stations is evaluated as to morning calling activity in Figure 3. The density-

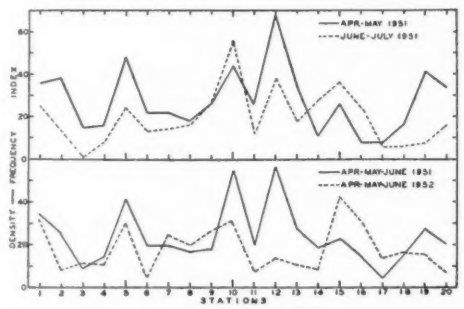

FIG. 3. Calling activity at stations based on 5-crew counts. Two periods in the same season and two seasons are compared. See text for explanation of index used. Note the moderately clumped distribution and the stability of the calling population.

frequency index used is the total number of doves heard at each station by all five crews multiplied by the number of crews (1 to 5) recording doves at the station. This index thus takes into account not only number of doves recorded but also consistency of calling during the census period. In the upper half of Figure 3, April-May are compared with June-July, the index for each station thus being based on two five-crew counts. It is apparent that there were no pronounced shifts in population along the route between April and July since the activity index remained roughly the same for each station. Thus, Stations 1, 5, 10, 12, and 15 which showed high calling activity during April and May remained the best stations in June and July. In the lower half of Figure 3, the two years are compared by averaging three counts (April, May, June) for each year. The two years differed more than the two periods in the same year, yet there was a general similarity in calling pattern. Stations 1, 5, and 10 tended to be high both years and Stations 3, 4, and 17 low both years. The index for some other stations, notably 12 and 15, was rather different.

It is interesting to note that one or two good stations alternated rather consistently with one or more poor stations all along the route (Fig. 3). This indicates that breeding doves were fairly evenly distributed along the route in both years, but tended to concentrate to some extent. This agrees with the general observation (Hopkins and Odum, 1953) that in Georgia doves show a moderate colony nesting behavior (several pairs often nesting close together), but do not concentrate in large breeding colonies, as has been reported from some midwestern and southwestern areas. Figure 3, perhaps, gives a good picture of the degree of clumping in the distribution of breeding doves in this area.

100-ACRE PLOTS. Table 1 shows the results of studies conducted on 100-acre

plots located at stations 2, 5, 9, 10, 16, and 20. The buffer area in Column 3 includes a narrow strip around the 100-acre plots in which breeding doves could be detected when cruising the 100-acre plots themselves. It was thought that doves in these buffer areas might be heard, at least part of the time, at the call-count station located in the center of each 100-acre plot. Coefficients of correlation, corrected for small number of items, between various columns in Table 1 are as follows:

1 and 3 .... 0.265
2 and 3 .... 0.775
1 and 4 .... 0.0
2 and 4 .... 0.202

Since the number of items is very small, it is the relative rather than the absolute values that may have meaning. Thus, correlation between call counts and actually located breeding doves was better with the population of 100-acres plus buffer (Column 2) than with the population of the 100-acre area alone. The best correlation was between doves on 100-acre plus buffer and doves heard at stations during the period when the area census was made (Columns 2 and 3). The ratio here is approximately one dove heard calling on the call-count for every 1.6 pairs found breeding in the vicinity. Since no evidence of breeding doves could be found at Station 20, yet at least one dove was heard at this station about every other visit, it would seem that the observer was recording doves at some distance beyond the boundaries of the 100-acre plot. Therefore, it seems likely that the presence of at least two breeding pairs within hearing distance is necessary to result in one dove being heard on the average at a morning call station during the peak of the season.

DISCUSSION

According to Peters (1952), call-counts using the same technic as used in this study were conducted in 11 southeastern states on 188 twenty-mile routes in 1951 and 1952. In northern and midwestern states 140 additional routes were run. Most of the routes, however, were run less than three times and only a few routes were surveyed intensively throughout the season. The average number of doves heard on 93 of his routes in the 11 southeastern states in 1951 during the presumed peak season was 15.5, and for 95 routes in 1952 the average was 21.4. The peak season averages in this study were 30.6 and 28.0, indicating that the route was located in better than average dove territory. However, it should be pointed out that in most of the cases reported by Peters, actual peak season was not determined; consequently, many counts may have been made before or after the actual plateau level. Also, it is apparent that there is considerable difference among observers in individual ability to hear doves. Comparisons, therefore, are best made by the same observer or by several observers working together.

Since calling activity along the 20-mile route maintained a reasonably constant level during the peak of the season in both years, it would appear that the call-count, if conducted at the proper time under good weather conditions (especially in regard to wind) is indeed a good index for determining the relative abundance from season to season, and thus a valuable aid in setting hunting regulations. However, the peak

season plateau proved to be unexpectedly short in duration in both years (Fig. 1), and was not constant in date of onset from one year to the next. A mid-point in the plateau of the curves, or around June 1, would seem to be the safest period if only a few counts are to be made.

June 1 is approximately the mid-point in the "peak-season plateaus" of curves obtained by Kerley (1952) in Tennessee, Duvall and Robbins (1952) in Maryland, and Wagner (1952) in Wisconsin. These observers conducted intensive studies of call-count routes for the 1951 season according to the same plan as used in the Georgia study. Thus, it would appear that there is no phenological north-south progression in peak season breeding (as might be expected from Hopkins' law), at least from latitude of Georgia piedmont to Wisconsin, even though doves start nesting earlier southward. The southeastern coastal plain and Florida may be a different story since Hopkins and Odum (1952) found the peak of nesting to be definitely earlier in south, as compared to north, Georgia.

In the more northern areas the peak season plateau tended to be longer in duration than was the case in Georgia. This agrees with the data on actual nesting obtained in area studies (Hopkins and Odum, 1952), which indicated that while the spread of the breeding season (and hence the period when some doves may be calling) is certainly greater in the south than in the north, the effective season (when most young are produced) is not longer, and, in fact, may be shorter in southern regions.

Both the Wisconsin and Maryland curves show a pronounced peak of calling in late April or May at or just before the beginning of the peak season plateau. As already indicated, a similar but less pronounced trend is shown by the Georgia data (Fig. 1). In Georgia, this highpoint in May corresponded in 1951 with the peak in actual nesting activity (i.e., the period when the largest number of pairs was engaged in some phase of nesting). Thus, competition for nest sites and mates was greatest at this time. It would be logical to expect that a pre-season peak in calling would be more pronounced in the north, where there would be little previous nesting activity (and hence no prior establishment of nest sites on territories).

Variability of calling activity encountered during the two-hour period of a count is probably not an important factor in finding a useful index for year-to-year comparisons as long as all counts are run in a standard manner by the same observer (or two or more observers to correct for differences in hearing ability). Only if there was a drastic shift in distribution of calling birds along the route might an appreciable error be introduced. Since both the two-year call-count study and two-year area study showed that breeding doves tend to return to traditional places for breeding, such a pronounced shift probably would not occur unless there was a large-scale change in habitat.

While morning peak season counts were consistently higher and less variable than afternoon counts, there is much to be said for the afternoon count as a practical index for future use in determining population trends. As shown in Figure 2, there is less time bias and, therefore, more equal sampling of all stations along the route. Most impor-

tant, however, is the fact that cooperation of wildlife rangers, busy state and federal personnel, and voluntary observers will likely be much greater with afternoon counts than with morning ones. Early morning counts during the long days of June are hard on the health of persons who have full-time duties in other matters!

As has been indicated, highest correlation was obtained between number of doves heard on call counts and breeding population on 100 acres plus a buffer strip of undetermined width. This indicates that doves beyond the limits of a 100-acre tract were often recorded at a call-station by this observer. It does not follow, however, that repeated three-minute listening stops accurately census more than 100 acres or even all of 100 acres. There are obviously too many variables to attempt, at our present level of knowledge at least, to convert time-relative density into space-relative density. It does seem possible that continued comparison of call-counts with area studies could result in an approximate calibration factor. Such a conversion factor would have to be worked out for each region separately since the degree of colony nesting or clumping of breeding birds will very much influence the results obtained with these or any other sample methods.

SUMMARY

1. Thirty-seven morning and 37 afternoon call-counts were made in 1951 between March and September, and 15 morning and 15 afternoon counts were made in 1952 between March and July over an experimental route in Oconee County on the piedmont region of Georgia. A count required two hours with three-minute listening stops at each station and three minutes of driving time between each station. Morning counts began one-half hour before sunrise; afternoon counts two hours before sunset. All doves heard and seen on the route were recorded. Monthly 5-crew counts were also made (April-August 1951; April-June 1952) in which observers started at the same time at Stations 1, 5, 9, 13, and 17. Finally, six 100-acre plots, each with a call-count station in the center, were censused by the spot-mapping method to determine correlation between calling activity and breeding population density.

2. A peak season plateau in morning call activity was evident both seasons with the highest counts occurring at the onset of the plateau. This plateau occurred approximately between May 15 and June 15 in 1951 and May 22 and June 20 in 1952. While the two seasons differed in timing the average calling population density was not significantly different when the respective peak seasons were compared.

3. The peak season plateau occurred at about the same time as reported in similar studies in Maryland and Wisconsin, but was shorter in duration. This agrees with area studies (Hopkins and Odum, 1952), which indicate that while the spread of the breeding season is certainly greater southward, the effective season (when intense breeding activity occurs) is similar, or even shorter, southward.

4. Afternoon counts, approximately one-third as high as morning counts, showed the same general seasonal trends and were more variable. (Average coefficient of variation for peak season both

years was 28.3; for afternoon counts, 9.2 for morning counts.)

5. Data from 5-crew counts indicated that calling activity definitely decreased during the second hour of the morning count, but did not change during the two-hour afternoon period.

6. Calling activity at stations indicated no pronounced shifts in breeding population during the season, and only a moderate change was indicated from 1951 to 1952. Calling birds were fairly evenly distributed along the route both years, but tended to congregate to some extent, i.e., a moderate colony nesting behavior was exhibited.

7. Correlation between call-counts and actual breeding population density was better with 100 acres plus buffer strips than with the 100-acre areas alone, indicating that doves beyond the limits of a 100-acre tract were often recorded by the observer. However, it is not yet possible to convert time-relative density into space-relative density.

8. Since a peak season plateau was evident, it is concluded that call counts, if taken at the proper time and in good weather, will provide a good index to relative abundance of breeding doves from year to year. Around June 1 was indicated as the best time if only a few counts are to be made.

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COLORED LEG BANDS FOR WATERFOWL

Ronald W. Balham and Wm. H. Elder [1]

University of Missouri, Columbia, Missouri

Previous studies of Canada geese (Elder and Elder, 1949) indicated the need for a permanent color marker for the identification of individual geese in the field. In the course of banding studies pursued at Horse Shoe Lake and with a captive flock of Canada geese in Illinois, a variety of color bands was tested, but none proved entirely satisfactory. They were of three main types: (1) commercial spiral celluloid bands as sold for poultry, (2) painted Fish and Wildlife Service bands which were dipped in either enamel or lacquer through which the original stamped numbers and wording could be easily read, (3) anodized Fish and Wildlife Service bands which were colored by the Alumilite process by the Chicago Thrift Co., 1215 West Washington, Chicago, Ill.

Use of celluloid bands of both the spiral and butt-to-butt types has been reviewed by J. T. Emlen (1950). While they have been useful with small birds, they have not proved satisfactory in our experience for geese because a large proportion of the bands was lost during the first winter when they became brittle due to cold. Even with those that remained, fading was so severe that color identification during the second winter could not always be made with certainty.

Use of paints and lacquers provided an excellent band during the first winter's observations but abrasion removed so much of the colored layer that positive field identification could seldom be made during succeeding winters.

Anodized bands are produced by a process similar to electroplating. The aluminum band functions as the anode on which aluminum oxide is formed. The oxide is an excellent mordant and takes up any dye in the electrolytic solution, thus making a permanent colored coating. When properly done the layer is transformed to aluminum hydroxide, having a hardness much greater than aluminum and nearly equal to that of corundum. Although this layer is harder than paint, it is subject to the same limitation: abrasion eventually wears it off. This fact caused us to abandon the use of anodized bands with geese. F. H. Hammerstrom has informed us (personal communication) that anodized bands have proven very satisfactory for prairie chickens (*Tympanuchus cupido*).

A new technique using a heavy plastic called Plexiglas has been devised and promises to provide a strong, permanent and brilliantly colored leg band for geese and other large birds.

Plexiglas is the trade name for rigid acrylic resin sheets, available in many colors, which are manufactured by the

[1] Contribution from the Delta Waterfowl Research Station, Delta, Manitoba, and from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation and University of Missouri cooperating.

Rohm and Haas Company, Washington Square, Philadelphia 5, Pennsylvania. The manufacturer claims that this plastic is unaffected by animal oils and greases, alkalies, acids, etc., and has excellent resistance to weathering. It may be easily formed by heating, and has a surface hardness approximating that of brass. It is stable under ordinary conditions, but should be stored away from excessive heat or solvent fumes such as may exist near paint spray and storage areas. It can be cut readily by the use of ordinary band, jig or circular saws. Circular saw blades should be eight to ten inches in diameter, 3/32 inch thick with six to eight teeth per inch alternately set and filed radially, and operating at 3400 r.p.m. For cutting sheets less than $\frac{1}{8}$ inch in thickness, it is preferable to use a saw which has little set.

Plexiglas is a thermoplastic, becoming pliable when heated to its forming temperature. It is then readily shaped, and, on cooling, will retain the shape to which it was formed. The optimum temperature was found to be about 300° F. Temperatures much in excess of this may cause surface bubbling.

For the construction of goose bands, sheets of plastic .125 inches in thickness were cut to measure $2\frac{3}{4}''$ by $\frac{3}{4}''$ which gives the same inside diameter as the Fish and Wildlife Service number 8 band used for Canada geese. The protective paper coat and adhesive were then removed and the long edges of the plastic strip smoothed off by scraping with a pocket knife. The ends of the bands which had been sawed at right angles to the long axis, were then bevelled against an emery wheel to reduce the angle to 85 degrees (Fig. 1). This is essential to ensure a perfect butt-to-butt closure around a goose's leg.

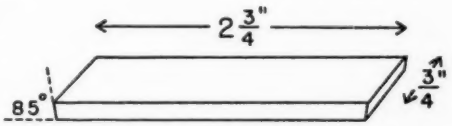

FIG. 1. Plexiglas strip cut and bevelled prior to forming.

The equipment required for banding geese in the field consists of a small oven, a source of heat, molding tongs, needle-nosed pliers, thin cotton gloves, rubber tape, a pail of water and the plastic cut to size as mentioned above.

The oven may be constructed from any square can with a base of approximately 6 by 6 inches, lined throughout with asbestos sheeting, and fitted with a door and a false bottom or shelf made of transite. The false bottom placed half an inch from the oven floor provides an air space between the source of heat and the plastic, thus spreading the heat, and ensuring that the material will be heated uniformly. This is important because of the differential rate of heat loss between the ends and the middle of the band during the forming operation. The oven was heated over a small single burner gasoline stove of the Coleman or Primus type.

Forming tongs were made by cutting in half a short piece of steel tubing of inside diameter $1\frac{1}{8}$ inch. These semicircular pieces were brazed onto the tips of fishhook disgorging pliers sold as "Sportsman's longnosed pliers" by Bartelt Engineering Company, Rockford, Illinois. (Fig. 2).

The prepared strips were heated in the oven to approximately 300° F. for about one minute. Experience in han-

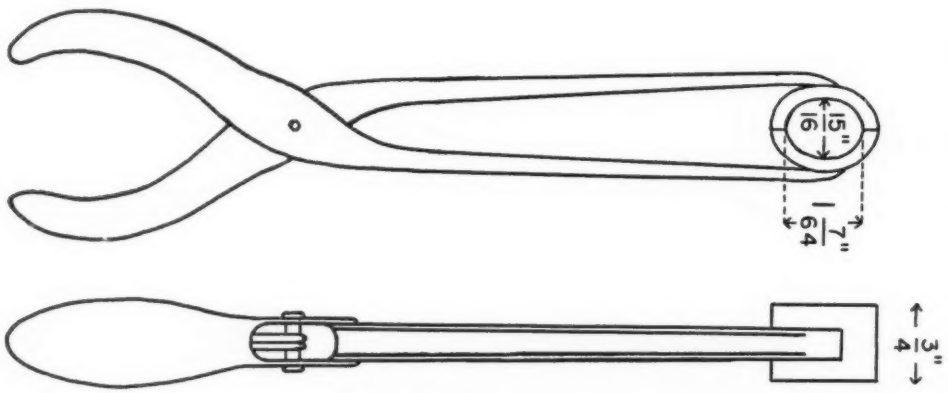

FIG. 2. The forming tongs.

dling the plastic will soon enable the operator to determine whether the consistency of the band is rubbery enough to mold easily around the bird's leg. A pair of needle-nosed pliers is useful in turning up one corner of the plastic to see if the consistency permits it to bend readily.

The assistant holds the goose firmly in his lap with its belly up, tail away, (Fig. 3). A five-inch strip of electrician's rubber tape is wrapped spirally around the leg to be banded, thus safeguarding it from any burns possible before the plastic cools.

When the consistency of the plastic is correct and the goose is firmly held and restrained by the assistant, the band is taken from the oven with needle-nosed pliers and rapidly transferred to the left hand. It should be held lengthwise between the thumb and first finger, and quickly wrapped around the leg and then shaped by the special tongs, taking care that the plastic meets butt to butt. This can be accomplished by using the gloved fingers of the left hand to align the ends of the plastic within the tongs. This operation should be carried out as quickly as possible for the material will cool below its forming temperature in less than one minute. Soft cotton gloves are worn to prevent the hands from

FIG. 3. Method of restraining goose while applying the colored leg band. Rubber tape has been wrapped around the leg; the ends of the band have been aligned and the leg is about to be submerged in water.

getting sore from the heat of the plastic.

The two operators then coordinate to submerge the leg (with the plastic still contained within the tongs) into a pail of water for a few seconds until the material sets by cooling. Once set, the band is permanent and cannot be removed except by using two pairs of pliers to break away the butted ends.

This technique was developed and used during a study in the summer of 1952 at the Delta Waterfowl Research Station, Delta, Manitoba. Tests for shattering and abrasion were made by standard sand-blasting for one minute during which Plexiglas showed no discernable change, while bottle glass of the same thickness was abraded completely away. Fading tests have been run for nine months on the colors red, green, white and yellow; these have shown no fading and may stand up to the manufacturer's claim of complete color permanency. The fast colors, brilliant hue and shiny surface of these bands make them very desirable for rapid field identification and it is hoped that they will provide permanent individual identification for waterfowl studies.

In our banding the Fish and Wildlife Service aluminum band is placed on the right leg of male birds, on the left leg of females. A colored band may be added above or below the aluminum band and one or two plastic bands of contrasting colors used on the other leg. With only the five best colors—red, yellow, white, green, and blue—combinations can be made that will provide individual identity of 250 birds of each sex.

For color banding of ducks a similar procedure was followed using Plexiglas of .06 inch thickness. The rapid cooling of this thinner material made it very difficult to form the band on the leg before the plastic lost its elasticity. However, it seems very likely that a plastic with slightly different thermal qualities could be found that would make the technique as useful for ducks as it has proven to be for geese.

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MUSKRATS IN RELATION TO FARM PONDS[1]

W. Walter Beshears, Jr.

Alabama Department of Conservation

and

Arnold O. Haugen

Leader, Alabama Cooperative Wildlife Research Unit, Auburn

There are approximately 10,000 farm ponds with an estimated 35,000 acres of fresh water impounded in Alabama (Byrd, 1952). The common muskrat (*Ondatra z. zibethica*) has become established in many of these ponds because they offer such important habitat requisites as a continuous supply of water at fairly constant levels, food and sites for burrows.

Most muskrats in farm ponds studied dug burrows for homes instead of building houses. Owners of ponds with muskrats have frequently complained of muskrat damage to their dams. Therefore, the primary objective of the study was to determine the effects of muskrat burrows on dams of farm ponds. Secondary objectives were to obtain information on productivity and economic value of farm pond muskrats. Field studies were carried on from October, 1950, through June, 1951.

Data were secured mainly from farm ponds located within 10 miles of Auburn, in Lee County, Alabama. The 143 ponds on the Agricultural Experiment Station of the Alabama Polytechnic Institute were available for study. Additional information was obtained by excavation of burrows in dams of several ponds in Bullock and Montgomery Counties, Alabama.

[1] This paper reports part of a study made in partial fulfillment of the M.S. Degree at Alabama Polytechnic Institute by Beshears. Research directed by Haugen.

Study jointly financed by the Alabama Polytechnic Institute, Alabama Department of Conservation, U. S. Fish and Wildlife Service, and the Wildlife Management Institute.

Methods

Excavation of Burrows: Pond dams and banks were carefully searched for muskrat burrows. A burrow to be excavated for detailed study was first examined to determine the number and arrangement of entrances. Location of the mouth of the burrow in relation to normal water level was recorded. Excavation was begun at the entrance and continued to the end of the burrow with measurements taken on the horizontal distance into the dam, total elevation from base of entrance to ceiling of highest point, average height and width, and size and location of nest cavities. The relationship of the end of the burrow to center line of dam was noted. Other data taken included the amount of freeboard (vertical distance from the water level to top of the dam), top width, and slope of the embankment. Observations were made on relationships of burrowing activity to type of soil used in construction. After they were excavated, all burrows were refilled to reduce erosion.

Tools and equipment used for excavation and measurement of muskrat burrows consisted of shovel, pick-axe, garden hoe with a 4-inch wide blade and a 3-foot handle, 50-foot steel tape, 6-foot steel tape, meter-stick, 6-foot handmade measuring stick, and hand level.

LIVE-TRAPPING: Live-traps baited with apples, carrots, and corn were placed at approximately 50-yard intervals. They were set in water from 1 to 2 inches deep around the margins of the ponds. The traps were of a box-trap type, 12 inches high, 12 inches wide, and 24 inches long, and covered by 5/8-inch mesh hardware cloth similar to those used by Haugen (1942). They were closed by a drop door which operated from a treadle. Traps were visited early each day.

HANDLING: Live-trapped muskrats were handled by means of a wire cone of the type used by Stuewer (1943). The live-trap was set on end, the wire cone was placed in the trap and slipped over the animal. Usually the animal would quickly run into the cone.

Each muskrat, after being examined externally for injuries and parasites, was ear-tagged, weighed, sexed, and released. Females were also examined for the absence or presence of the vaginal membrane, lactation, and pregnancy. Muskrats that were taken for the first time were marked with numbered tags attached to the ear (National Band and Tag Company, tag No. 1005, Size 3). Re-catches of previously tagged animals were recorded.

BURROW STRUCTURE

Of 89 private farm ponds investigated, 41 were found to contain muskrats. Dams of 11 of these ponds contained burrows of which 50 were excavated and measured. Forty-four were in dams with 12-foot top widths while six were in dams with top widths ranging from $2\frac{1}{2}$ to 8 feet. Six additional burrows in the natural banks of ponds were opened for study. Our findings, based on these studies, are summarized in Table 1.

BREEDING ACTIVITY

SEX AND AGE RATIOS: A total of 127 individual muskrats was handled during trapping operations on farm ponds. In the total sample, all age classes combined, there were 66 males and 61 females, a ratio of 108 males : 100 females.

This greater catch of males was especially noticeable during the trapping season from November 20, 1950 to February 20, 1951, when 54 of 100 muskrats taken were males, a ratio of 117 males : 100 females. The sex ratio among 27 muskrats handled during the spring and early summer months was 80 males : 100 females.

Males were separated into age groups on the basis of size and appearance of reproductive organs, as described by Errington (1939). By this method, 11 (29%) of the animals handled during the trapping season were found to be adults and 27 (71%) were subadults.

Of 33 females examined during the trapping season, 10 (30%) showed placental scars and were classified as adults while 23 (70%) showed thin, translucent uteri and were regarded as subadults.

LITTER SIZE: Four litters handled during the investigation averaged four young. Placental scars were found in the uteri of 10 of the 33 females autopsied in the trapping season. Number of scars per female ranged from a minimum of

TABLE 1.—SUMMARY OF DATA ON MUSKRAT BURROWS

	Av.	Max.	Min.	No. Burrows on which based
Number of entrances	2	9	1	56
Distance between entrances	3′6″	8′	12″	39
Distance of entrance below water surface	6″	2′6″	0	56
Horizontal penetration of burrow into dam (12′ top)	5′2″	9′	2′	44
Horizontal penetration (2′6″—8′ top width)	4′10″	7′	2′2″	6
Horizontal penetration of bank burrows	4′10″	6′	4′	6
Rise in elevation (Dam burrows)	2′6″	4′2″	6″	50
Rise in elevation (Bank burrows)	1′4″	2′	10″	6
Distance from ceiling of burrow to ground surface	10″	2′2″	2″	56
Height of burrow cavity	6″	10″	4″	56
Width of burrow cavity	8″	10″	6″	56
Nest cavities per burrow	2	6	1	48
Distance from end of burrow to center of dam (12′ top)	6′	12′	12″	44
Distance from end of burrow to center of dam (2′6″—8′ top)	1′6″	4′	0	6

three to a maximum of 23, with an average of 12.7. This indicates an average production of approximately three litters per year per female. However, the ratio of five subadults to each adult female indicated a loss of seven to eight young between birth and the trapping season.

EVIDENCE OF WINTER BREEDING: Three young muskrats which weighed 13, 15, and 16 ounces were trapped during the week of January 18–25, 1951. It is estimated they were between 4 and 6 weeks of age. A 17-ounce kit trapped on March 31, 1951, was estimated to be about 6 weeks of age. This evidence indicated that at least a limited amount of breeding by muskrats occurs in central Alabama during winter months.

RANGE OF ACTIVITY OF FARM POND MUSKRATS

Information on range of activity of muskrats was secured from animals retrapped at more than one trapping station. Most animals re-caught were taken at the same trapping station at which originally marked. One tagged female was re-caught in the same trap on 16 consecutive nights.

Based on 286 recaptures of 56 tagged muskrats on a 59-acre pond, the average known range of activity was approximately 50 yards, with a maximum of roughly 500. This, however, does not indicate a true home range as most of the animals were not recaptured a sufficient number of times to determine this. It merely indicates that movements of most of the muskrats at that winter season were localized.

Apparently some muskrats abandon their homes in spring. A male that was live-trapped on February 25, 1951, was recaptured on March 29 about 8 miles from where originally taken. One large creek and several small streams were crossed by this animal during its migration. This muskrat then continued wandering and was next recaptured on

a third pond about one-half mile from where taken the second time. A similar tendency for movement was noted by Shanks and Arthur (1952) in Missouri, and Haugen (1944) in Michigan, who reported peaks of movement in spring and fall.

A pair of muskrats was live-trapped on a 2-acre pond in October and again in December. These animals were not recaptured when the pond was live-trapped again the following May. There is a possibility that the animals may have been lost through predation. On another farm pond of 3 acres, three males and two females were handled in November, and again in February. The two females were recaptured in May, 3 months later, but none of the males were recaptured. However, another adult male, which had not been handled previously, was tagged during the latter period of live-trapping.

DISCUSSION

PATTERN OF BURROWING: Investigation of muskrat burrows showed that, in general, all muskrats followed a similar pattern in burrowing activity. Typical burrows began about 6 inches beneath the water surface, went in a short distance, and turned upward. Slope of the burrow was then maintained at about the same slope as the side of the dam which was usually 2: 1. Entrances to the burrow were connected at a point inside the dam above water level. Short branch burrows usually were found at various points along the main tunnels. Nest cavities were found usually at the end of certain branch burrows. Bank burrows followed a similar pattern.

In burrows with more than three entrances. a cross-tunnel connected entrance passageways. This connecting tunnel ran parallel with the dam, and usually was about 2 feet in from the entrances. Branch burrows also connected with the main tunnel.

SOIL PREFERENCES FOR BURROWING: Muskrats apparently exercise some selection in soil type for making burrows. Information from a series of five ponds in sandy clay loam soil in Montgomery County showed that most functional burrows were concentrated in one dam and part of another that were more clayey in texture, while the dams of a sandy texture contained mostly old, abandoned burrows. These abandoned burrows had caved as a result of heavy rainfall, high wave action, and trampling by fishermen. This resulted in the dam edges sloughing off and silting into the ponds.

DAMAGE CAUSED BY FARM POND MUSKRATS: Most farmers seemed to fear that muskrats would cause washouts in dikes and dams. Many were not aware that muskrats already were present in their ponds. When informed of the presence of muskrats, they always asked: (1) had the animals burrowed into the dam, (2) what was the extent of damage, and (3) how could they get rid of the animals. It was evident that most of these pond owners were more concerned with possible damage than they were about possible fur values. They considered the question only on the basis that muskrats are a nuisance and that the thing to do is to get rid of them as quickly as possible.

This fear of potential damage to the pond dam was the basis for complaint by most owners. Repeated efforts were made during the study to find farm ponds where muskrats had burrowed

through the dams and caused leaks or washouts. County Agents, State Department of Conservation personnel, and others questioned in Alabama, provided no evidence of washouts of dams as a result of muskrat burrowing. There remains the possibility, however, that such washouts can occur as a result of burrowing, especially where the dams are narrow.

Damage to earthen dams with 12-foot top widths was found in very few instances. Such damage, where it did occur, was usually the result of the burrows caving because of sandy soil. Heavy rains, severe wave action, and cattle and fishermen walking over burrows caused these cave-ins which resulted in the loosened soil and subsequent erosion. In some instances, large gaping cavities were found in sides of dams where dogs, in pursuit of muskrats, had excavated burrows.

Considerable damage has resulted from muskrat burrows in unusually narrow dikes and dams of special ponds on the Agricultural Experiment Station. Muskrats frequently tunnel through these narrow dikes and thereby ruin fish experiments in progress. Besides damage to dikes and dams on experimental ponds, muskrats sometimes have been reported to hinder fish investigations by muddying water in small ponds. It is probable that some minnows and small fish used in the experiments have been destroyed by muskrats. Fish culturists report that muskrats sometimes consume soybean and cottonseed meal cakes that are placed in ponds as food for fish.

The owner of a hatchery for the production of bait minnows located at Decatur, Alabama, reported some damage caused by cave-ins of muskrat burrows in the dikes and dams of his hatchery pond. He also believed some of his bait minnows and fish food were eaten by muskrats. It would seem advisable not to tolerate muskrats in minnow-producing ponds since damage and potential damage by them probably would be greater than the fur value of the animals.

PROTECTIVE MEASURES AGAINST DAMAGE BY FARM POND MUSKRATS: Where muskrats are a nuisance in farm ponds, probably the best method of control is by steel-trapping. They are easy to trap and can be entirely removed from such small impoundments. Where possible such trapping should be confined to the open season for muskrats.

Several pond dams investigated were found to contain some form of riprapping along the edge at the water level. Riprapping usually consisted of a tier of logs from 6 to 10 inches in diameter, a layer of rocks, or in some instances, strips of tin, placed along the slope of the dam at the water's edge to prevent caving by wave action. No burrows were found in dams of this type, and it is believed that such construction discouraged muskrats from burrowing. Riprapping obviously is expensive. However, it appears advisable to carry out such a protective measure on dams that have top widths of 8 feet or less, or where muskrats have burrowed to such an extent that there is danger of a breakthrough.

Dams constructed of well packed clay soil with top widths 12 feet or more across and slopes with a rise of one foot or less for each 2 feet of horizontal distance were found to offer best assurance

against appreciable damage by muskrats.

ECONOMIC VALUE OF FARM POND MUSKRATS: The greatest number of muskrats found on a farm pond was 67 on a 59-acre pond. However, live-trapping on one 3-acre pond netted seven muskrats, or 2.3 per acre. The owner of this pond reported he had steel-trapped nine muskrats from the pond the previous trapping season. The owner of another farm pond reported steel-trapping 23 muskrats from his 2.5-acre pond, a harvest of 9.2 muskrats per acre. Such a harvest compares favorably with those from some of the best natural muskrat marshes.

Seventy-four pelts from farm pond muskrats sold at public auction in New York in April, 1951, at an average price of $2.80 each.

Accordingly, muskrats are a natural resource in farm ponds and may yield cash income to pond owners or to farm boys in many sections. The animals are relatively easy to harvest and provide additional income, sport, and pleasure for individuals who wish to trap.

SUMMARY

This report is based on field studies from October, 1950 through June, 1951. Eighty-nine farm ponds were examined, of which 41 contained muskrats. Fifty burrows were excavated in the 11 ponds that had signs of digging.

Results indicate that: (1) in general, muskrats followed a similar pattern in burrowing activities: the average muskrat den had two entrances; it entered the bank roughly 6 inches under water, then penetrated upward and into the dam a distance of 5 feet, 2 inches with a rise in elevation of 2 feet, 6 inches. The average burrow still lacked by 6 feet reaching the center of dams with 12-foot top widths; (2) muskrats apparently exercise some selection in the type of soil in which they make their burrows; (3) only slight damage, usually the result of burrows caving because of sandy soil, was found in dams with 12-foot top widths; (4) best assurance against appreciable damage by muskrats is dams constructed of well packed, clay soil with tops at least 12 feet across and slopes with a rise of one foot or less for each 2 feet of horizontal distance; (5) owners of ponds which contained muskrats were more concerned with possible damage than possible fur value. Probably the best method of control of muskrats in farm ponds is by steel-trapping.

A sex ratio of 108 males : 100 females was found on the basis of 127 muskrats handled during trapping operations. Breeding potential of the farm pond muskrats was indicated by an average of 12.7 placental scars per female and an average litter size of four young. The trapping season population was made up of 70 per cent young-of-the-year.

Three young muskrats taken in January and one in March, estimated to be 4 to 6 weeks of age, indicated at least a limited amount of breeding during winter months.

Based on 286 recaptures of 56 tagged muskrats, the average distance between points of capture was approximately 50 yards, with a maximum of roughly 500. Movements of muskrats into and out of farm ponds were noted, primarily during spring months. One male migrated a distance of approximately 8½ miles.

The owner of a 2.5-acre pond harvested 23 muskrats, or 9.2 per acre, during one season. Pelts from 74 farm pond muskrats taken in central Alabama sold at public auction in New York at an average price of $2.80 each. Muskrats are a valuable natural resource in farm ponds, and will provide additional income, sport, and pleasure for those who wish to harvest them.

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PREPARATION OF FISH TISSUES FOR GROSS BETA RADIOASSAY [1, 2]

Louis A. Krumholz [3]

Tennessee Valley Authority

and

A. H. Emmons [4]

Oak Ridge National Laboratory

[1] This work was done in the laboratories of the Waste Disposal Research Section of the Health Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee, under the supervision of the Fish and Game Branch, Division of Forestry Relations, Tennessee Valley Authority, Norris, Tennessee, sponsored by the U. S. Atomic Energy Commission, Contract No. AT(40–1)–221.

[2] Published with permission of the Tennessee Valley Authority.

[3] Present address: P. O. Box 2105, Oak Ridge, Tennessee.

[4] Present address: Radiological Safety Department, University of Michigan, School of Public Health, Ann Arbor, Michigan.

This paper describes an efficient wet digestion technique for the routine preparation of fish tissues for determination of gross beta radioactivity. The method is particularly suited to samples of tissues containing non-volatile, long-lived radioactive fission products. Being primarily a volumetric method, most of the tedious weighing procedures that accompany routine radioassay are eliminated. Previous to the instigation of this method for preparation, samples were ashed at high temperatures with result-

ing ignition losses that were difficult to evaluate. Wet digestion methods using sulfuric acid produced copious precipitation of calcium sulfate that was difficult to work with in routine. Methods employing perchloric acid necessitated so much attention to the preparation of individual samples that large numbers of samples could not be conveniently handled.

In the preparation of animal tissues for radioassay the following criteria should be met: (1) the sample should be large enough so that there will be sufficient radioactive material present to be measured with reasonable accuracy; (2) the tissue in the sample should be transformed into an inorganic homogeneous mass; (3) the sample being prepared for counting should be spread evenly over the bottom of the counting dish and dried thoroughly; and (4) the thickness of the dried sample on the counting dish should be such that there will be a minimum of self-absorption.

PREPARATION OF SAMPLE

1. Calibrate a numbered series of 25 milliliter glass-stoppered Erlenmeyer flasks to volumes of 5 and 10 milliliters and etch the calibrations on the flasks. Weigh the flasks without glass stoppers on an analytical balance. Such tare weights will usually remain constant through several sample digestions.

2. Place the sample of tissue to be assayed in the flask and determine the gross weight of flask and sample. Samples of one or two grams of tissue have proved adequate where the tissue under study is one of which there is an ample supply, such as flesh, bone, or scales. Here, however, the amount of radioactivity per unit sample weight will determine the size of the sample needed (large samples result in large self-absorption corrections). In any event, a maximum sample weight of 5 grams should be sufficient because if there is no measurable radioactivity in such a sample there is little need for further study by these techniques. Tissues such as the heart, kidney, or spleen, constitute only a limited weight, and therefore, digestion of the entire organ is recommended.

3. Add 5 to 6 milliliters of concentrated nitric acid (HNO_3) and allow to stand until the tissue is dissolved (overnight is usually sufficient). After the tissue is dissolved, heat gently to 38–40° C. on a hot plate and reduce the volume of the sample to 1 or 2 milliliters. Any foaming in the flask can be effectively controlled by adding a drop or two of 0.1 per cent Aerosol solution and removing from the heat. Consistently better results have been obtained by using a temperature not greater than 60° C. over a relatively long period rather than using higher temperatures for shorter periods. Higher temperatures cause more violent boiling and possible loss of sample material through spattering.

4. When the volume of the sample has been evaporated down to 1 or 2 milliliters, remove the flask from the heat and add a drop of 30 per cent hydrogen peroxide (H_2O_2) solution to oxidize the organic material. Here, caution should be used so that the reaction will not cause the sample to boil over. Resume heating and continue the addition of hydrogen peroxide, a few drops at a time until the solution becomes colorless. When the solution remains colorless for 10 minutes with continued heating and without the addition of more peroxide,

all of the organic material has been oxidized. The samples should not be heated to dryness. When dryness is approached, distilled water may be added.

5. Allow to cool, then make up the volume to 10 milliliters with distilled water by the calibration previously etched on the flask and mix well. If only a very small amount of tissue is available, and the amount of radioactivity suspected is small, the volume may be made up to only 5 milliliters rather than to 10. Suspended oil or fat globules in our studies appear to contain little or no radioactivity. If any fat soluble isotope is suspected, the fats may be extracted with ether and assayed separately.

6. Aliquots may be pipetted out on stainless steel dishes for counting or the solution may be counted in a liquid counter.

PREPARATION OF MOUNT FOR COUNTING IN AN END-WINDOW GEIGER-MUELLER COUNTER

1. Shake the sample well to assure complete mixing.

2. Pipette duplicate one milliliter aliquots into stainless steel counting dishes. Consistently good results have been obtained using dishes one and one-eighth inches inside diameter with a capacity of about two milliliters. The angle between the bottom and sidewalls of the dish is rounded to an one-eighth inch radius to lessen the amount of creep of the solution into the corners of the dish. The dish has a quarter-inch flange at the upper edge that serves as a tab for handling and numbering. The duplicate aliquots usually give comparable results and serve to corroborate each other as indicated by the data in Table 1.

TABLE 1.—COUNTING DATA FOR VARIOUS SELECTED FISH TISSUES SHOWING THE CONSISTENT DUPLICATION OF COUNTS FROM DUPLICATE ONE-MILLILITER ALIQUOTS FROM A 10-MILLILITER SAMPLE. ALL COUNTS HAVE BEEN CORRECTED FOR BACKGROUND

Tissue	Dish number	Recorder reading	Lights	Time, minutes	Counts per minute	Average counts per minute
Scales	71 a	215	58	20	691	
	71 b	215	54	20	691	691
Skin	74 a	9	60	20	32	
	74 b	10	40	20	34	33
Muscle	75 a	12	57	20	41	
	75 b	13	24	20	43	42
Eyes	76 a	17	53	20	57	
	76 b	18	24	20	59	58
Liver	80 a	44	39	20	143	
	80 b	45	1	20	144	144
Compact bone	89 a	110	23	20	353	
	89 b	111	26	20	357	355
Vertebrae	90 a	81	55	20	262	
	90 b	84	2	20	269	265

3. Thoroughly dry the sample in the counting dish. Samples that are air-dried at a temperature of about 30° C. give consistently good results. Samples dried under an infra-red lamp or other source of high heat tend to boil and spatter and considerable amounts may be lost.

4. Remove when dry, cool, and count. Reliable results have been obtained by counting on the second shelf of an end-window Geiger-Mueller counter at a geometry of approximately 10 per cent depending on the particular counter used.

Either one of the sample dishes may be used to determine the correction for self-absorption by adding the remaining volume of the sample one milliliter at a time, drying, and counting between additions (Table 2, Fig. 1). The extrapolation of the initial slope of the plot of radioactivity as a function of the sample volume gives the required correction.

If the remainder of the sample is not used for the determination of correction data for self-absorption, it may be used for radiochemical analysis. If an individual sample of a particular tissue does not contain enough radioactive material for radiochemical analysis, similar samples of the same tissues may be pooled and concentrated for such analysis.

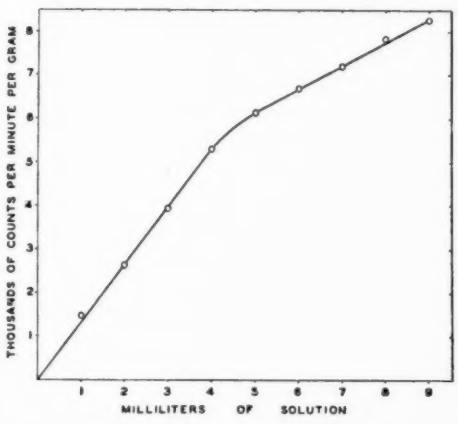


FIG. 1. Radioactivity in fish scales indicated as a function of sample volume showing self-absorption. This is a graphic representation of the data in Table 2.

In addition to the work on fish, samples of tissues of many invertebrates, various amphibians, reptiles, and birds have been prepared with equal success.

TABLE 2.—DATA FOR CORRECTION FOR SELF-ABSORPTION OF SAMPLE OF FISH SCALES. ALL SAMPLES WERE COUNTED FOR 20 MINUTES. ALL COUNTS WERE CORRECTED FOR BACKGROUND. THESE DATA ARE GRAPHICALLY REPRESENTED IN FIGURE 1.

Milliliters of sample solution	Recorder reading	Lights	Counts per minute	Correction for coincidence	Counts per minute corrected for coincidence
1.....	462	12	1459	11	1470
2.....	819	1	2596	34	2630
3.....	1214	34	3864	75	3940
4.....	1623	53	5173	134	5310
5.....	1870	40	5966	178	6140
6.....	2027	49	6469	209	6680
7.....	2184	54	6969	243	7210
8.....	2369	29	7582	286	7870
9.....	2566	3	8211	335	8550

The method has given satisfactory results for more than 15,000 tissue samples.

We are indebted to Mrs. Venus I. Knobf of the Oak Ridge National Laboratory and to Messrs. William T. Miller and Edwin R. Eastwood of the Tennessee Valley Authority for their assistance in the preparation of samples.

TECHNIQUES FOR MASS CAPTURE OF FLIGHTLESS BLUE AND LESSER SNOW GEESE

Graham Cooch [1]

Department of Conservation, Cornell University, Ithaca, N. Y.

In the summer of 1952, a preliminary study was made of blue and lesser snow geese on breeding grounds at the mouth of the Boas River, Southampton Island, N. W. T., Canada. It was believed desirable to band as large a number of geese as possible in order to determine the migration routes and winter range of the Southampton Island population, to give an indication of hunting pressure in the United States and Canada, and to aid in studies of color inheritance and plumage change.

Through the centuries, Eskimos on Southampton and Baffin Islands developed an efficient method for trapping flightless geese by driving them into rude enclosures. Goose drives were made in conjunction with fall caribou hunts. Since the last caribou on Southampton Island were extirpated in 1946, thus eliminating the reason for Eskimos to visit the remote goose colonies, goose-trapping is no longer done. A similar condition has evidently come about on Baffin Island (Soper, 1930). Knowledge of the driving technique among natives on Southampton Island is now limited to one family.

Family groups of geese congregate into large flocks as the post-nuptial molt approaches. Eventually loose bands of up to 500 pairs and their progeny will be seen scattered over the tundra. Although flightless, they are able to run with great speed. It is possible for a man to run down individual birds, but any attempt to capture large numbers in this way would lead only to frustration.

The Eskimo technique is simple but effective. A trapping drive is initiated by a group of men running in a course which nearly parallels that of a large band of geese (Fig. 1). The birds see figures loom up on the horizon, but unless it becomes immediately apparent that these figures are running directly toward them, they merely slowly walk away from the disturbance. If the hunters should try to run directly at the geese, the chance of trapping many is lost. The objective is to cause the geese to circle, and to surround them by dropping men at intervals from the group that is running outside of, but parallel to the circling group of birds (Figs. 2 &

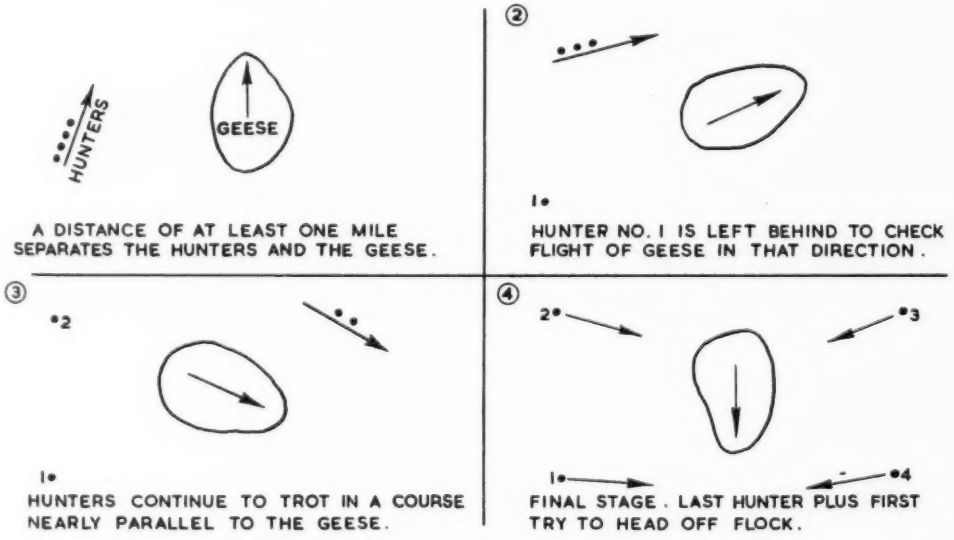
[1] Grateful acknowledgment is made to the Arctic Institute of North America and to the Naval Research for providing funds for this study.

3). These men check retreat of the birds so they are kept circling in the same general direction. Unless this can be accomplished the birds will become frightened and scatter. It is often necessary for one member of the party to run quickly ahead of the flock in order to complete the circle of men. The men who have been left behind stay hidden until it becomes apparent that one member of the group has headed the flock and that they are now starting to run back. No matter which way the geese turn, they are blocked by figures suddenly looming up on the horizon directly in the path of their advance. The geese become confused and for a few moments dash frantically toward the largest gaps between the men. Gaps are easily closed by men heading off the geese. Finally the geese become completely muddled and give up (Fig. 4). They stand in a vast milling mob, cackling so loudly that any vocal communication among the hunters is impossible. The birds are now under control.

Once the geese have been placed in this position they are kept under control and are herded into a corral. The men, with one exception, walk towards the flock. The other man acts as a leader and walks away from the geese, never looking back. The geese move away from the men walking toward them and follow the one who is apparently retreating.

It was this method that the Eskimos used in making their long drives. Tales are still told of trips of several days duration, stopping when the geese were tired, then continuing until the destination was reached. It was possible thus to lead a small flock into a tent. This was actually accomplished in 1952 when a small flock was needed for study purposes.

The stone corrals in which the Eskimos trapped their birds were not very



FIGS. 1, 2, 3, and 4. Diagrams illustrating Eskimo method for trapping flightless geese.

imposing structures. The walls were waist high and the enclosures perhaps twenty feet in diameter; the elaborate leads so common to banding operations in the south were virtually nonexistent. The man leading the flock walked through the entrance and climbed over the other side. The geese crowded into the pen, those on the bottom being killed in the crush. Maunder (1852) reports that natives in certain parts of Siberia used a similar technique in goose trapping. A modification of this technique was used in the banding operations in 1952.

Many explorers have noted the presence of stone corrals or *Kugees*, far from present areas of breeding concentration. Some have stated that perhaps these indicated areas of past breeding abundance. However, on the basis of information given me by Eskimos on Southampton Island, and corroborated by experience, the *Kugees* were often built at camp sites and the geese moved to camp rather than the camp moved to the geese. Therefore the interpretation of stone corrals as indications of past breeding colonies may not be valid.

The method used in banding drives in 1952 took advantage of the extensive tidal flats of the Bay of God's Mercy (Fig. 5). Two or three men walked out onto the flats until out of sight of camp. They then walked parallel to the coastline until they believed that a large segment of the flock had been headed off. This party was greatly aided by the presence of a small island a few hundred yards off shore which permitted the party to approach the geese and still be concealed. These rocks also provided vantage points for estimation of position, as well as number of birds. A second party of two men remained at camp until it was believed that the coastal

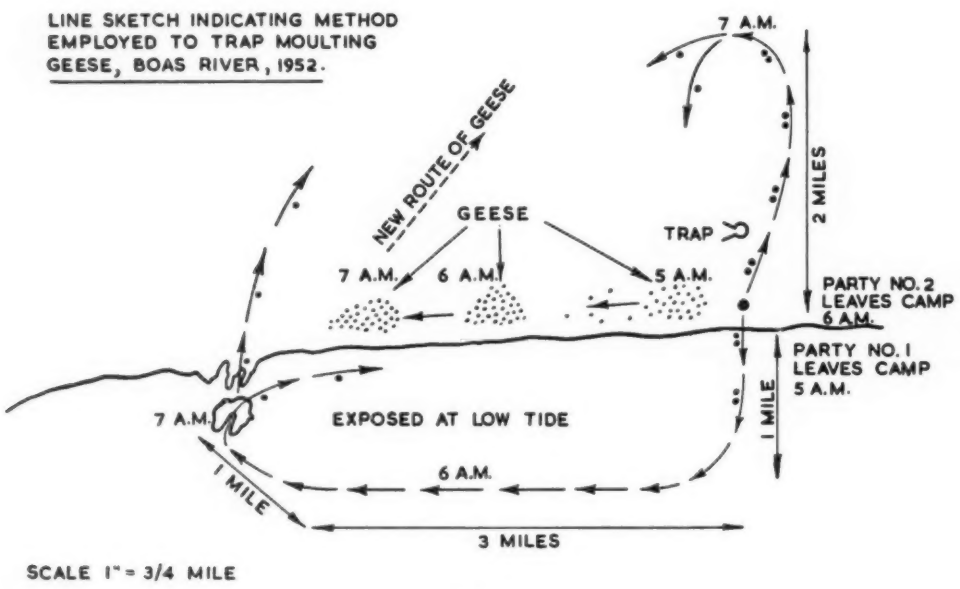


FIG. 5.

party had proceeded far enough. Then they proceeded to a point about two miles inland and split; one man ran along a course parallel to coast, while the other walked slowly in the general direction of the island. Eventually the two parties came in sight of one another, or at least the geese which were being herded by the coastal party were seen on the horizon. Thus the birds were trapped between two groups of men almost before they sensed the disturbance. Vigorous running was required only in the first few minutes after the men on the island had started to head off the birds feeding along the shore. Once this feat had been accomplished it was merely a matter of walking the birds back to the trap.

The effectiveness of this method was demonstrated on two occasions when 15,000 birds were under control, of which 5,000 were in the main pen. With adequate manpower and some luck it would have been possible to band 25,000 geese in 1952 at the Boas River colony.

Construction of an adequate trap was simple (Fig. 6). The pen, 50 yards in circumference, and leads 100 yards long were made of two-inch mesh, heavy nylon netting; in sections four feet high. The net was held upright by five-foot bamboo poles, held firmly with rocks and clay sods. The central receiving pen was re-enforced with one-inch mesh poultry wire, 24 inches high, which prevented the geese from getting their wings and feet entangled in the nylon netting. A small "V" inside the larger pen was used to trap small segments of the flock for banding.

A shallow creek in front of the leads was dammed to form a small pond of approximately ten acres. Although this water barrier was not more than six inches deep, it was useful in the event that the geese became nervous as they approached the net and started to run

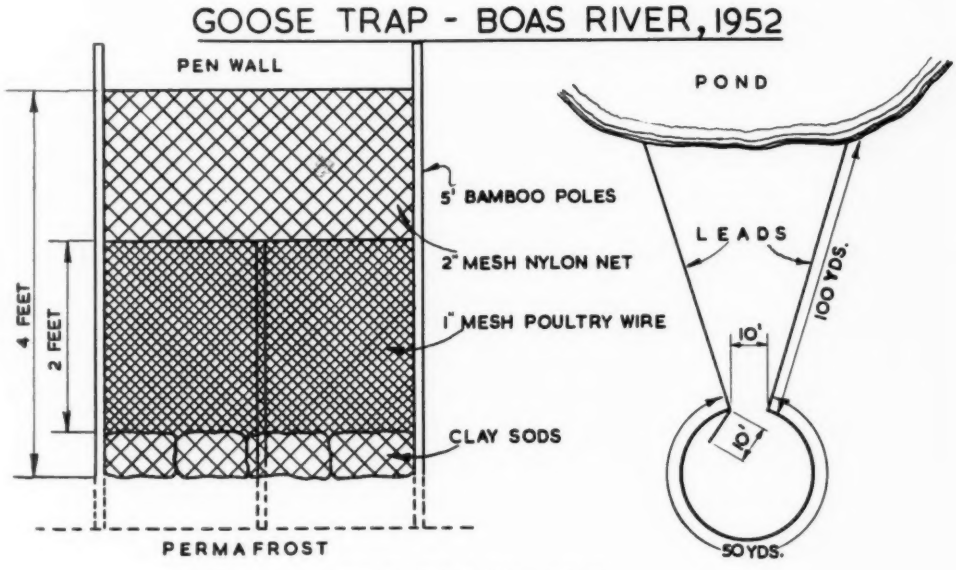


FIG. 6. Detail of goose trap.

or reverse their direction. The water was not deep enough to permit swimming but was sufficient to slow them down considerably. It offered no hindrance to the longer-legged men and any attempt to escape was easily thwarted.

It is unfortunate that time did not permit the sexing of every bird banded. However all were aged and those breeding birds which retained the so-called yearling plumage throughout the postnuptial molt were color-banded.

We still have much to learn about the best way to band large numbers of geese without destroying too many in the process. The presence of 5,000 geese in a restricted pen at one time is a dangerous situation (Fig. 7). Young bird ares knocked over and trampled, others become fatigued or die of shock. The rate of banding loss appears to increase by geometric progression with each additional hour the birds are kept in the pen. The worst loss occurred on August 1, 1952, when 78 young and 19 adults were killed in a flock of 5,000. Perhaps it would have been wiser to wait another week before banding the young birds, although there was a chance that adults might have regained the power of flight. More frequent drives, with more men, would reduce the numbers of birds in the pen as well as periods of confine-

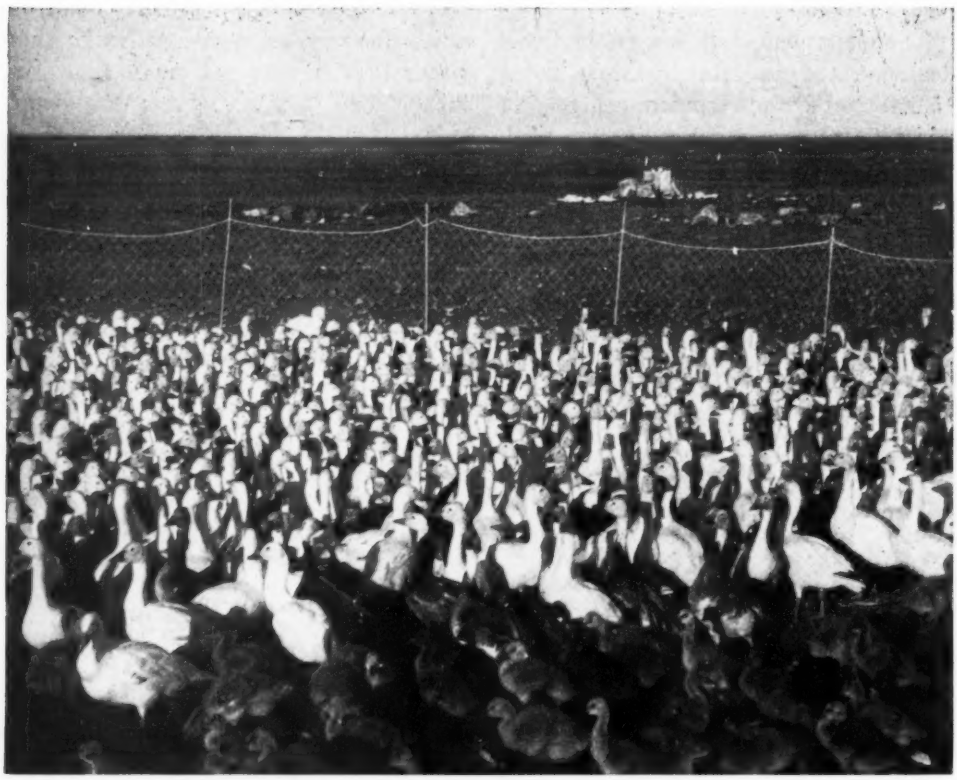


FIG. 7. Trapped blue and lesser snow geese with young in foreground.

ment. The goslings are large enough to band with U. S. Fish and Wildlife Service 7B bands at three weeks of age. These birds as well as their parents start to fly six weeks from the date of hatching and frequently before that. Future banding of downy young blue and lesser snow geese should be so timed that trapping takes place from the fourth week after hatching until the geese are flying. By that time the young would be better able to fend for themselves if separated from their parents.

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MIGRATION AND MORTALITY OF DUCKS HAND-REARED AND WILD-TRAPPED AT DELTA, MANITOBA

George K. Brakhage [1]

Duck Creek Wildlife Area, Puxico, Missouri

The Delta Waterfowl Research Station (formerly the Delta Duck Station) was established at Delta, Manitoba, in 1931 by James Ford Bell. Through his resident manager, Edward Ward, he attempted to increase the waterfowl productivity of the Delta Marsh by rearing and releasing ducks hatched from eggs collected from wild nests. This attempt was based on the belief that the normally single-brooded female duck could be induced to produce two broods a season: one reared artificially and the other naturally when she renested after her first eggs were taken to the incubator.

This paper presents an analysis of banding data procured during a twenty-one-year period of hand-rearing and wild-trapping of ducks at the Delta Marsh. Four species are involved in the analysis: mallard, (*Anas platyrhynchos*), pintail, (*A. acuta*), redhead, (*Aythya americana*) and canvasback, (*A. valisineria*). The purpose of the analysis is to compare the fates of ducks hand-reared from wild eggs with those of the same species trapped in the wild in order to determine whether rearing in artificial surroundings alters a bird's ability to migrate or increases its vulnerability to the gun.

In seeking an answer, patterns of migration of hand-reared and wild-trapped birds were compared. In addition, speeds of migration and homing propensities were investigated. Mortal-

[1] Contribution from the Missouri Cooperative Wildlife Research Unit: U. S. Fish and Wildlife Service, Wildlife Management Institute, Missouri Conservation Commission, Edward K. Love Foundation, and the University of Missouri cooperating.

ity of juveniles during their first fall season has been studied, and special emphasis has been placed on the importance of local hunting pressure.

ACKNOWLEDGMENTS

I wish to express my gratitude to H. Albert Hochbaum, Director, Delta Waterfowl Research Station, Delta, Manitoba, for suggesting the study and allowing free use of unpublished material, and to A. S. Hawkins, U. S. Fish and Wildlife Service, for the use of unpublished data. Others who gave aid and advice are John W. Aldrich and Seth H. Low, U. S. Fish and Wildlife Service, C. E. Shanks, Missouri Conservation Commission, and Joseph J. Hickey, University of Wisconsin. I wish to thank William H. Elder, University of Missouri, under whose direction this study was made.

REVIEW OF LITERATURE

The survival of hand-reared waterfowl on this continent was first discussed by Lincoln (1934). He concluded from band recoveries that mallards hand-reared on game farms did not disperse from the point of release and did not survive at the anticipated rate. Expecting a first year recovery of about 12 per cent (based on recoveries from 125,000 wild-trapped ducks of all species), Lincoln found that the rate from 3,500 liberated game-farm mallards was only 1.5 per cent. Errington and Albert (1936) reported a similar failure of game-farm mallards to migrate or contribute to the hunter's bag.

McCabe (1947) demonstrated in Wisconsin that wood ducks (*Aix sponsa*), hand-reared from wild eggs did migrate as expected and, in addition, returned to their marshes of liberation the following spring. Barnes (in McCabe, 1947) reported similar results in Indiana.

In regard to migration, Valikangas (1933) found that the sedentary English mallard, when transported and reared in Finland, migrated and homed as native Finnish mallards. However, Hornberger (1934) demonstrated with storks (*Ciconia ciconia*), that there was an inherited directional migratory behavior. Some 237 young storks were taken from their nests and transported to an area outside the normal migratory range of their parents, and there raised by foster parents. These transported juveniles were found to migrate in their ancestral direction.

Williams and Kalmbach (1943) reported the migration and fate of transported juvenile waterfowl. They concluded that ducklings of several species, when transported to other flyways, did not show an innate affinity for their ancestral flyway but adopted the migratory habits of the birds among which they had matured.

The New York Conservation Department has attempted to establish breeding populations of mallards in several areas throughout the state by releasing game-farm birds (Benson, 1939; Kutz, Mason and Taber, 1948; Darrow, 1949; Wells, 1951). Direct band recoveries (those received the first fall after banding) averaged about 13 per cent. However, 75 to 90 per cent of these recoveries came from within twenty-five miles of the liberation sites, suggesting that the high rate of recovery was a result of intensive local hunting pressure. Kutz, Mason and Taber commented, ". . . the paramount contribution of the stock liberated was toward improved local

hunting during the fall immediately following release."

MATERIAL

The banding operations which provided the data for this study were carried out at the Delta Marsh. Hand-reared ducklings were banded and liberated in the marsh when six to twelve weeks old. Originally the young birds were released directly on the marsh without conditioning or protection of any sort. This resulted in heavy pre-hunting losses. Later a gentle release

TABLE 1.—NUMBER OF JUVENILE HAND-REARED DUCKS BANDED AT DELTA AND NUMBER OF RECOVERIES

	Mallard		Pintail		Redhead		Canvasback	
Year	Banded	Recovered	Banded	Recovered	Banded	Recovered	Banded	Recovered
1932	327	27	305	41	...	..	180	25
1933	36	4	96	22	271	15	141	7
1934	224	25	255	38	190	14	179	8
1935	317	17	486	46	149	3	174	3
1936	336	19	518	28	110	1	41	1
1937	262	17	300	11	100	6	96	10
1938	159	22	150	21	54	5	77	5
1939	148	40	87	16	...	..	...	..
1940	67	14	51	9	40	0	30	2
1941	95	15	62	11	65	5	...	..
1942	...	..	...	..	...	..	44	0
1948	36	4	75	11	...	..	...	..
1949	...	..	168	30	...	..	...	..
1950	...	..	66	10	56	10	...	..
Total	2,007	204	2,619	264	1,035	59	962	61

TABLE 2.—NUMBER OF JUVENILE WILD-TRAPPED DUCKS BANDED AND NUMBER OF RECOVERIES

	Mallard		Pintail		Redhead		Canvasback	
Year	Banded	Recovered	Banded	Recovered	Banded	Recovered	Banded	Recovered
1938	51	9	44	6	7	3	...	..
1939	29	4	10	4	3	1	...	..
1940	...	..	...	..	20	3	...	..
1941	12	2	...	..	...	..	...	..
1946	3	1	...	..	...	..	...	..
1947	7	0	9	2	...	..	...	..
1948	717	184	416	74	301	57	...	..
1949	373	70	319	30	313	62	13	5
1950	657	111	174	26	262	50	5	2
1951*	1081	83	931	45	526	65	1	0
Total	2,930	464	1,903	187	1,432	187	19	7

* Recoveries are not complete for 1951. These data were used for migration investigations but not for mortality computations.

technique was employed, the birds being liberated on a pond enclosed by a predator-proof fence. Here they mingled with pinioned birds and visiting wild birds. As soon as able, they flew freely to and from the pond, eventually joining wild flocks to migrate. Band recoveries from these hand-reared birds provide the material for basic comparisons made in this study.

Recoveries from wild-trapped ducks are a result of the banding program of the Delta Waterfowl Research Station and the U. S. Fish and Wildlife Service at the Delta Marsh. The wild-trapped birds were captured between mid-July and late October, the majority being taken during August and September.

Both the experimental hand-reared birds and the wild-trapped controls were banded as juveniles at the Delta Marsh.

In order to obtain the most complete and up-to-date information, the original banding information was reviewed and recovery data collected at the Patuxent Research Refuge, Laurel, Maryland. Tables 1 and 2 show the number of birds banded and the accumulated recoveries from these bandings.

MIGRATION FINDINGS

FLIGHT PATTERNS: Aldrich *et al* (1949) have presented accumulated information from the banding files of the U. S. Fish and Wildlife Service concerning the flight patterns of sixteen species of waterfowl. As far as possible, they used only direct recoveries to outline flight lanes because of the greater proba-

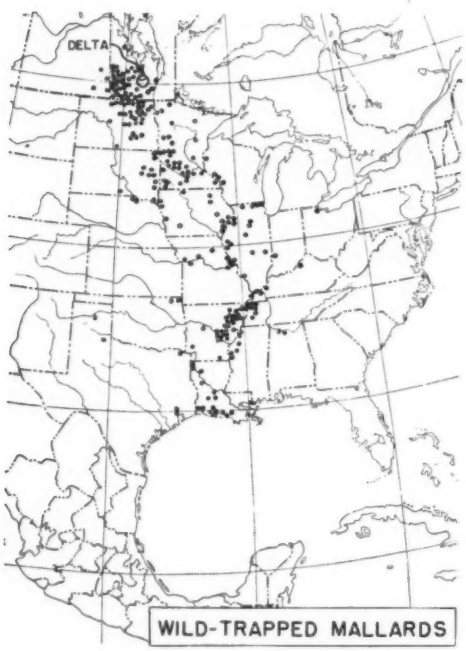

FIG. 1. Fall migration route of juvenile wild-trapped mallards from Delta, Manitoba, established by 201 direct recoveries.

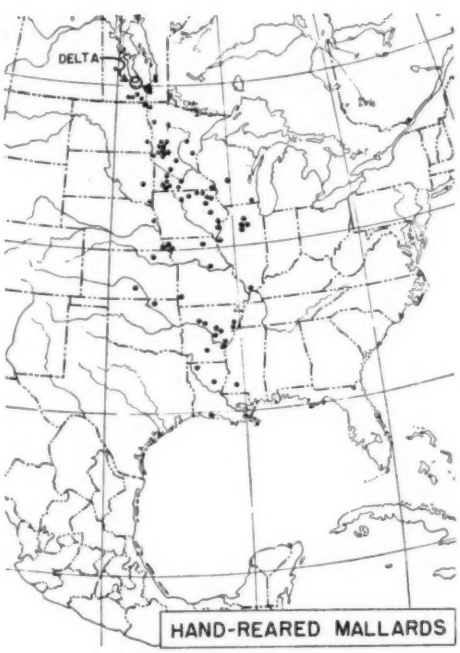

FIG. 2. Fall migration route of juvenile hand-reared mallards from Delta, Manitoba, established by 97 direct recoveries.

bility that such birds had flown in but one general direction between banding and recovery. In this study, only direct recoveries from juvenile birds have been used for analysis of migration.

In Figures 1 through 6, the migration routes of the wild-trapped and hand-reared juvenile birds from Delta are presented for comparison. It should be remembered that these birds were on their maiden migratory movement and did not have the benefit of previous migratory experience.

Scrutiny of these maps will reveal that the flight patterns of hand-reared birds fall well within those delimited by the wild-trapped birds. In no case has the hand-reared cohort established a different flight lane to the wintering grounds. The patterns of migration of Delta Marsh wild-trapped birds do not differ from those published by Aldrich *et al* for Manitoba.

In Figure 5 the split migration of the redhead from Manitoba is clearly shown. This peculiarity was first discussed in part by Lincoln (1939: 159), but it remained for Robbins (in Aldrich *et al*) to define clearly the routes and assess their importance. Although the sample is small, canvasbacks (Fig. 6) seem to show a split migration pattern like that of redheads.

COMPARISON OF MIGRATION SPEED: To compare migration speeds of hand-reared and wild-trapped ducks, a mean date of band recovery was computed for each geographic zone traversed by each species in fall migration (Fig. 7). Four latitudinal zones divide the flight

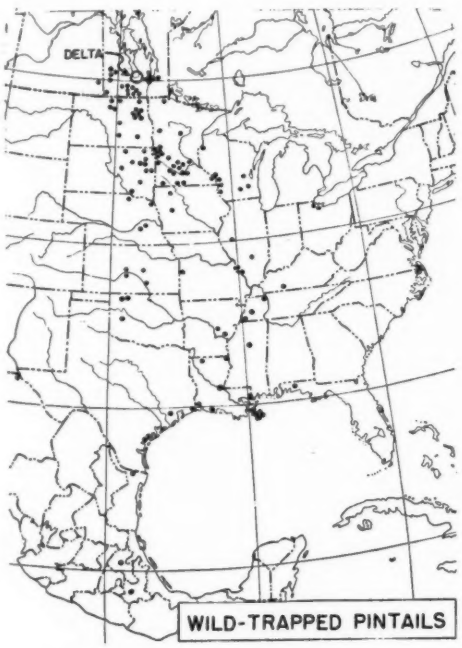

FIG. 3. Fall migration route of juvenile wild-trapped pintails from Delta, Manitoba, established by 129 direct recoveries.

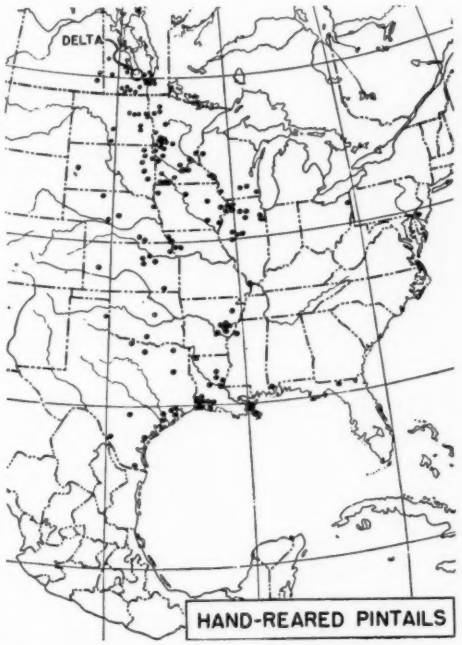

FIG. 4. Fall migration route of juvenile hand-reared pintails from Delta, Manitoba, established by 169 direct recoveries.

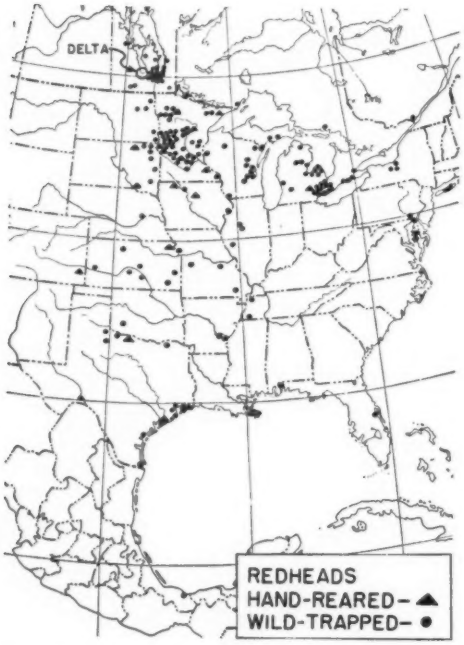

FIG. 5. Fall migration route of juvenile redheads from Delta, Manitoba, established by 171 direct recoveries from wild-trapped birds and 19 direct recoveries from hand-reared birds.

FIG. 6. Fall migration route of juvenile canvasbacks from Delta, Manitoba, established by 5 direct recoveries from wild-trapped birds and 23 direct recoveries from hand-reared birds.

lanes into bands of approximately equal width. In the case of redheads and canvasbacks, where a split migration is indicated, the eastern route is divided into two additional longitudinal bands. The numbers of days elapsed between an arbitrary base date of September 1 and the dates of band recoveries were summed and the mean computed for each zone. For example, three bands recovered on the following dates, September 23, October 9, and October 16, would have been from ducks killed twenty-three, thirty-nine and forty-six days respectively after the base date. The sum of these is 108, the mean, thirty-six, and the average date of recovery October 6, or thirty-six days after the base date.

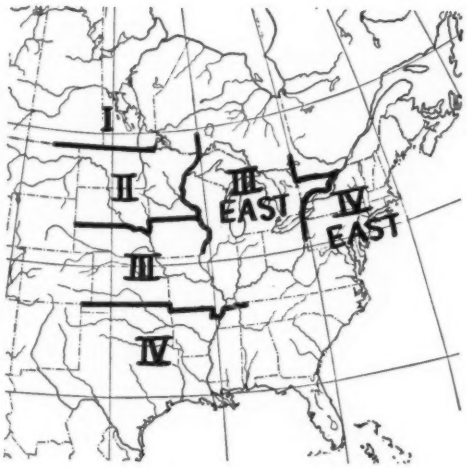

FIG. 7. Latitudinal and longitudinal zones used to compute speed of migration.

TABLE 3.—AVERAGE DATE OF BAND RECOVERY BY GEOGRAPHIC ZONES. BASED ON DIRECT RECOVERIES FROM JUVENILE BIRDS, BUT EXCLUDING THOSE FALLING WITHIN A FORTY-MILE RADIUS OF DELTA, MANITOBA

	Wild-trapped			Hand-reared		
	Average Date	No.	Per Cent	Average Date	No.	Per Cent
Mallard						
Zone I	Oct. 17	35	16	Oct. 23	11	14
Zone II	Oct. 25	74	34	Oct. 29	28	36
Zone III	Nov. 12	44	20	Nov. 28	24	31
Zone IV	Dec. 9	62	29	Dec. 7	15	19
		215	100		78	100
Pintail						
Zone I	Oct. 11	19	17	Oct. 7	17	12
Zone II	Oct. 17	50	44	Oct. 23	47	34
Zone III	Nov. 5	17	15	Nov. 1	36	26
Zone IV	Nov. 30	27	24	Dec. 1	38	28
		113	100		138	100
Redhead						
Zone I	Oct. 5	20	14	.....	..	..
Zone II	Oct. 23	47	32	Oct. 30	8	44
Zone III (South)	Nov. 8	13	9	Nov. 4	3	17
Zone IV (South)	Nov. 22	18	12	Nov. 30	4	22
Zone III (East)	Oct. 24	37	26	Nov. 9	3	17
Zone IV (East)	Nov. 26	10	7	.....	..	..
		145	100		18	100
Canvasback						
Zone I	.....	..	..	Sept. 23	3	14
Zone II	.....	..	..	Oct. 28	4	18
Zone III (South)	Too few recoveries	..	..	.....	..	..
Zone IV (South)	.....	..	..	Nov. 23	5	23
Zone III (East)	.....	..	..	Nov. 13	6	27
Zone IV (East)	.....	..	..	Jan. 1	4	18
		5			22	100

The results of these computations are presented in Table 3. While a slower migration speed in the hand-reared birds might have been anticipated, it was not demonstrated by the findings. That there was no consistent variation of any magnitude in the two cohorts indicates that time of departure and speed of migration are essentially the same for hand-reared and wild-trapped ducks. No significance was attached to the variations in the small samples because the birds were largely banded in different decades. The difference shown by

the table for hand-reared and wild-trapped mallards suggest the value of new releases of hand-reared mallards in the same decade with the wild-trapped sample.

COMPARISON OF HOMING RATES: Until recently there has been considerable doubt as to whether wild ducks returned to their natal marshes to nest. Lincoln (1939: 74) wrote, "Despite the great juvenile mortality, the weight of banding data appears to indicate that 'homing instinct' does not operate until after the individual has nested and that the location of the first nest is largely a matter of chance in obtaining possession of unoccupied territory." Nice (1931), Hickey (1943), Farner (1945), and Lack (1946) have demonstrated that certain passerines home to the general vicinity of their birthplaces. Sowls (1951), in the course of his studies of duck nesting at Delta, found that about 13 per cent of 115 liberated hand-reared female pintails returned to the area of release the following spring. If these hand-reared birds suffered mortality at the anticipated rate (see below), only thirteen birds should have returned. Fifteen birds did return; this suggests that a high proportion of the surviving individuals homed to their natal marsh to nest.

Another measure of homing in wild-trapped and hand-reared birds is the total number of recoveries from birds shot in the vicinity of the Delta Marsh in years after the first fall (indirect recoveries). Although the samples are small, examination of Table 4 reveals that the homing rate is apparently higher for hand-reared mallards and pintails than for wild-trapped birds of the same species. Certain biases are present, however, when fall band recoveries are used to demonstrate homing. (1) A portion of the birds that did return to the Delta Marsh area to nest left on their southward migration before the shooting season opened at Delta and therefore were not available for sampling. (2) The recoveries that do come from the vicinity of the Delta Marsh are undoubtedly in part from transient adults that nested well away from Delta but gathered there again prior to migration and lingered into the shooting season. (3) The wild-trapped sample is also composed of transient juveniles which tend to depress the apparent homing rate for wild-trapped birds because some that probably homed to nearby birthplaces did not return to Delta for the "pre-migration" gathering. It is probable that if the wild-trapped sample had been composed ex-

TABLE 4.—INDIRECT RECOVERIES FROM DUCKS BANDED AS JUVENILES AT THE DELTA MARSH AND RECOVERED IN THE SAME MARSH

Species	Origin	Total number recovered	Number recovered at Delta	Per cent recovered at Delta
Mallard	Wild-trapped	76	12	16
	Hand-reared	16	3	19
Pintail	Wild-trapped	34	9	26
	Hand-reared	49	19	39

clusively of locally reared birds, homing rates for hand-reared and wild-trapped birds would have been approximately the same.

MORTALITY FINDINGS

MORTALITY RATES: The technique developed by Bellrose and Chase (1950) was used in this study to measure mortality. Because Manitoba is the origin of the samples studied, no correction for latitudinal position such as they employed in Illinois was necessary. Unfortunately the rates of band recovery found in this study can not be compared with those found by Bellrose and Chase, and others, because a complete accumulation of band recoveries was not made during the early years of the artificial liberation program at Delta. An unknown, but reportedly large, number of ducklings died soon after release and their bands were neither gathered nor reported. This precludes the possibility of making the usual computation of the percentage of birds banded that were recovered. However, pre-season losses have no bearing on mortality rates as computed by the Bellrose-Chase method.

While conclusions concerning migration rates and homing as drawn in this study are probably valid for the species as a whole, mortality rates probably vary with geographic location. For this reason mortality computations should be considered as indices for each species rather than empirical figures universally applicable.

In Table 5 are presented the results of the mortality computations. Incomplete year-classes were omitted from the total banded sample. No conclusions have been drawn regarding mortality rates beyond the direct recovery period because sampling limits are not yet available for this type of data.

LOCAL MORTALITY: Another method of analysis was employed to discover possible differences in hunting mortality sustained by wild-trapped as compared with hand-reared birds. The percentage of the total direct recoveries which were from ducks shot locally (within a 40-mile radius of Delta) were compared for the two groups. From the results presented in Table 6 it is obvious that the hand-reared birds suffered a larger percentage of their total mortality

TABLE 5.—MORTALITY RATES OF JUVENILE WILD-TRAPPED AND HAND-REARED DUCKS BANDED AT DELTA, MANITOBA, AS COMPUTED BY THE BELLROSE-CHASE METHOD

Species	Origin	Number banded	First-year mortality rate in %	Per cent difference
Mallard	Wild-trapped	1,686	70	
	Hand-reared	2,007	91	+30
Pintail	Wild-trapped	971	66	
	Hand-reared	2,619	89	+33
Redhead	Wild-trapped	906	80	
	Hand-reared	1,035	94	+18
Canvasback	Wild-trapped	18	..	
	Hand-reared	962	93	....

TABLE 6.—PERCENTAGE OF TOTAL DIRECT RECOVERIES WHICH WERE OBTAINED WITHIN A 40-MILE RADIUS OF THE BANDING SITE

	Wild-trapped			Hand-reared			
Species	Total direct recoveries	Number of local recoveries	Per cent local recoveries	Total direct recoveries	Number of local recoveries	Per cent local recoveries	Percentage hand-reared exceeded wild-trapped
Mallard.....	233	81	35	177	86	49	40
Pintail.....	109	21	19	225	70	31	63
Redhead.....	147	40	27	53	36	68	152
Canvasback ..	6	1	..	55	34	62	...

in the Delta Marsh area than did wild-trapped birds. While other workers have found a high percentage of their total recoveries coming from the vicinity of the banding station (Pirnie, 1941; Mann, Thompson and Jedlicka, 1947; Van Den Akker and Wilson, 1949), the significant finding in this study was that during the direct recovery period, Delta hand-reared birds were recovered at a greater rate on their natal marsh than were wild-trapped birds. Hand-reared mallards were recovered locally at a rate 40 per cent greater than that found for wild-trapped mallards, pintails were recovered locally at a rate 63 per cent greater, and redheads at a rate 152 per cent greater than were wild-trapped birds of the same species.

DISCUSSION

The cause for the failure of most waterfowl stocking programs is not entirely clear. It has been suggested that birds from game-farm stock, long selected for tameness, have lost inherited characteristics essential for survival in the wild. This has been thoroughly demonstrated in the wild turkey (*Meleagris gallopavo*) (Gerstell and Long, 1939; Leopold, 1944). Another suggestion offered in explanation for the lack of thrift in game-farm birds is their "taming" due to association with man during their juvenile period. Behaviorists have pointed out the ease with which young birds accept and follow the first animate object they see (Heinroth, 1910). This "imprinting" to humans may dull a bird's innate sense of wariness or upset some congenital behavior pattern essential for survival.

From the evidence presented it seems clear that ducks hand-reared from wild eggs migrate in a fashion similar to normally reared wild birds. Once the hand-reared birds have left the vicinity of the Delta Marsh, migration progresses at a normal rate over traditional routes to traditional wintering grounds. Sowls (1951) has shown that females return to their natal marshes the following spring.

But what are the management implications regarding migration and homing? If there is practical value to be derived from the release of hand-reared stock other than satisfying the local gunner on an immediate basis, it must be realized through the return of birds to nest. If the surviving individuals return to their marshes of liberation to nest in the

following years and thus replace a "burned out" breeding population or colonize a new area, a long term value will be realized. But it can not be considered sound management to stock birds which do not survive long enough to reproduce.

It seems evident from data presented in Tables 5 and 6 that hand-reared birds suffer a higher mortality than do wild-trapped birds. In each case the mortality rates in the first year of life are from 18 to 33 per cent higher for hand-reared than for wild-trapped birds. The hand-reared birds are from 40 to 152 per cent more vulnerable to hunting pressure on their marsh of release than are wild-trapped birds.

The detrimental effects on duck populations in marshes where eggs are gathered for artificial incubation can not be ignored. In river ducks, which renest readily (Sowls, 1949, 1951), the productivity of a marsh may not be greatly altered. But in bay ducks, such as redheads and canvasbacks, renesting has not been demonstrated conclusively. When considering the length of time required to put young diving ducks on the wing (Hochbaum, 1946), any renesting that does occur is of questionable value, particularly on marshes such as Delta where the freeze-up occurs relatively early and shooting pressure is heavy. In addition, the early departure of male redheads and canvasbacks for their moulting areas may deprive the renesting female of the opportunity of remating and laying a fertile clutch. Therefore, removal of eggs may contribute toward "burning out" a marsh's breeding population as does early, heavy shooting.

The value of using ducks hand-reared from wild eggs for re-stocking purposes has not been completely assessed. While this paper gives some indication of their ability to migrate and their vulnerability to hunting pressure, it remains for careful experimental liberations in a variety of habitats and geographical locations to fully evaluate the technique. Until such time it would be quite unwise to launch an expensive artificial liberation program. From an economic standpoint, most conservation agencies cannot afford to stock ducks before the gun. Channeling funds into development, restoration or improvement of habitat seems more justifiable, and more biologically practical, than releasing hand-reared stock.

SUMMARY

(1) Banding data gathered over a 21-year period at the Delta Waterfowl Research Station, Delta, Manitoba, were analyzed to determine the effects of hand-rearing on the migration patterns and mortality rates of wild ducks of four species: mallard, pintail, redhead and canvasback.

(2) The migration routes of wild-trapped and hand-reared birds, as determined by direct recoveries from juvenile birds, were plotted on maps. There were no major differences in migration patterns noted between the two groups. The hand-reared birds did not depart from the traditional migration routes followed by wild-reared ducks from the Delta Marsh.

(3) Migration speeds were determined on the basis of average date of band recovery in each of a series of geographic zones. From the data analyzed, there appears to be essentially no difference between wild-trapped and hand-reared birds regarding departure date and rate

of progress down the flyways during autumnal migration. The only exception is that hand-reared mallards may migrate somewhat later than do wild-trapped mallards.

(4) Homing tendencies were measured by comparing the per cent of indirect recoveries received from hand-reared and wild-trapped birds during fall shooting seasons in the Delta Marsh area, and the biases of this method were discussed. Waterfowl hand-reared from wild eggs home to their natal marsh at a rate similar to wild-trapped birds banded on the same marsh.

(5) Mortality was consistently higher for hand-reared than for wild-trapped ducks. Mallards had approximately 30 per cent, pintails 33 per cent, and redheads 18 per cent higher direct mortality rates than did wild-trapped birds of the same species. There were too few wild-trapped canvasback recoveries to make comparisons, but the hand-reared birds had a mortality rate similar to hand-reared redheads.

(6) Vulnerability to local shooting pressure was investigated in both groups by comparing the rates of local band recovery during the first fall after banding. The data show that hand-reared birds are more vulnerable in the area of release than are wild-trapped birds captured in the same area. At the Delta Marsh, local mortality of hand-reared birds, as based on direct recoveries from juvenile birds, exceeded that found for wild-trapped birds by the following magnitudes: mallards, 40 per cent; pintails, 63 per cent; and redheads, 152 per cent. There were too few wild-trapped canvasback recoveries to make comparisons, but the hand-reared birds were recovered locally at about the same rate as were hand-reared redheads.

(7) Ducks hand-reared from wild eggs are more suitable stock for experimental liberation than game-farm birds because of their ability to retain a normal migratory behavior pattern. However, when considering the high mortality of hand-reared birds, the deteriorating effects on the populations in marshes where wild eggs are gathered, and the expenditures necessary to promote an artificial liberation program, the release of ducks hand-reared from wild eggs can not be recommended as a practical management technique.

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SOME HATCHING CURVES FROM DIFFERENT AREAS OF MICHIGAN'S PHEASANT RANGE [1]

Ralph I. Blouch and L. L. Eberhardt

Game Division, Michigan Department of Conservation, Lansing, Michigan

The development of methods for determining age in weeks of juvenile pheasants has permitted the construction of hatching-frequency distributions. These so-called hatching curves portray the history of the year's successful nesting and permit analysis on a much larger scale than is possible from nest observations. Hatching curves can yield much valuable information on the timing of

[1] A contribution from Pittman-Robertson Wildlife Research Project W-38-R, Game Division, Michigan Department of Conservation. Presented at the 14th Midwest Wildlife Conference, Des Moines, Iowa, December 17–19, 1952.

the nesting cycle and on departures from the ideal, single-peaked distribution of the nesting effort. Abnormalities that may appear can then be related to definite periods of time, and responsible factors sought out.

To be of any practical use, age data should be collected on a large enough scale to permit grouping into units of similar habitat. Hatching curves will then reflect conditions from fairly homogeneous areas, and their analysis will not be confused by overlapping of several sets of conditions.

In Michigan a Pittman-Robertson research project has been gathering pheasant age data on a wholesale basis during the past three hunting seasons. Hatching distributions have been worked up for the 1950 and 1951 seasons, and curves constructed for a number of areas of pheasant habitat. Both of these years were average for pheasant productivity, although the 1951 season appeared to be somewhat better than that of 1950. The purpose of this paper is to present some actual hatching curves that have been constructed from the 1950 and 1951 data and to point out the rather obvious need for resolving state-wide data into separate and more homogeneous units.

Age data has been obtained from pheasant wings and feet sent in by hunters in postpaid 7 in. by 10 in. envelopes. Instructions are printed on the reverse side of each envelope along with spaces for the hunter to record date and locality of the kill. About 40,000 of these envelopes have been distributed yearly since 1950. They are sent to sportsmen's clubs and selected hunting license dealers prior to the hunting season, and are also passed out by department personnel to hunters in the field. Returns have averaged around 4,000, or 10 per cent, each year.

In aging the specimens, adults are first separated from juveniles by means of spur length and appearance. Age of the juveniles in weeks is then determined from the stage of primary feather molt. Hatching dates assigned to specimens are arranged in frequency distributions and plotted as hatching curves. Information on locality in which the birds were taken is furnished by most of the donors. County names are usually given, and frequently the nearest town is also named. Such data permit analysis on an area basis, and the desirability of such a breakdown will be seen from the examples that follow.

Michigan's pheasants, with minor exceptions, are confined to the southern half of the Lower Peninsula—the agricultural region of the state, comprising some 40 counties. Within this portion of the state pheasant populations range from excellent to very poor. They can be grouped into at least five classifications of population density, roughly conforming to differences in land types. For the sake of convenience in handling survey figures, which are usually obtained on a county basis, 28 counties have been fitted into these five classifications. While artificial, since they depend on civil boundaries, the resulting groups of counties represent a working classification of pheasant range types. Results of numerous population surveys have conformed acceptably to this grouping of counties.

Figure 1 shows the location of the five survey areas. Included also in the diagram are some rural mail carrier brood count figures for 1951. These are in terms of average number of broods seen

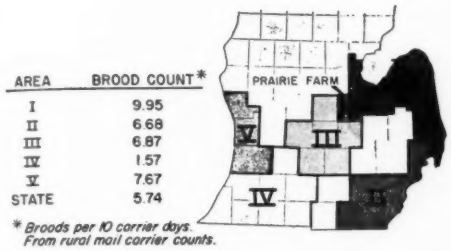

FIG. 1. Pheasant survey areas, showing 1951 brood densities.

in ten days of mail carrier driving, and they will serve to represent the comparative density of pheasant populations in the areas.

Area I, the state's best pheasant region, consists largely of lake plain soils, with some rolling moraine and till plain land in the interior. Climate in this area is somewhat cooler and drier, and the growing season is shorter than in the other areas. Highest pheasant populations are found on the heavy soils bordering Saginaw Bay and Lake Huron. In this so-called Thumb area pheasants reached a very high level, even nuisance proportions, during the peak years of the early 1940's. There also they fell off most sharply in the decline from 1945 to 1947. Although recovery following the slump has been slower than in many other areas, and pheasant numbers are still considerably lower than in the boom years, the region is again Michigan's top pheasant producer.

At the other extreme, Area IV is the poorest part of the state's pheasant range. Principally outwash plain and moraine in origin, the land there supports a second and third rate agriculture. In general, the climate of the area is somewhat warmer and the growing season is longer than in any of the other four areas. Pheasants in these counties have been at a consistently low level for as long as we have records. They fell off moderately during the slump years and have since increased to about the same level as before the decline.

The other three areas lie between these two extremes with regard both to current population levels and to fluctuation during the recorded periods of high and low numbers. In the following discussion comparisons will be made only between Areas I and IV, the two extremes. However, most of our survey information has indicated a distinct gradation of population levels among all five areas. No satisfactory explanation of these differences has yet been uncovered, but we believe that analysis of hatching curves from the areas for a series of years may provide a key to the problem.

State-wide hatching curves for 1950 and 1951 are compared in Figure 2. It

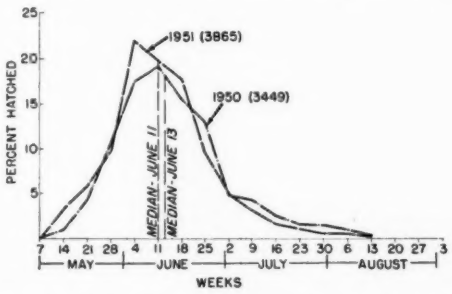

FIG. 2. Pheasant hatching distribution; statewide; 1950 and 1951.

will be seen that they are similar in most respects, conforming rather closely to a normal distribution skewed to the right. The 1951 curve is somewhat higher and narrower, with a one-week earlier modal peak than that of 1950, but with only a slightly earlier median or numerical mid-point. The rather flattened and

distorted top portions of the curves suggest the possibility that both may be composites of two or more distinct distributions. Both consist of very large samples collected from some 40 counties and representing all qualities of pheasant range.

In Figure 3 the 1950 hatching data

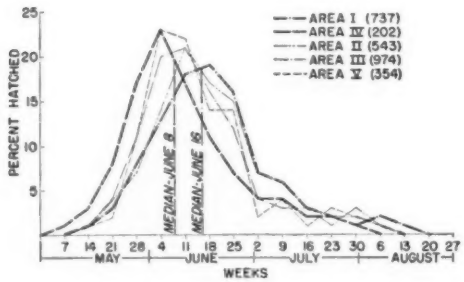

FIG. 3. Pheasant hatching distribution; five areas; 1950.

has been separated by area. Sample size for each area, shown in parentheses, seems sufficiently large to provide satisfactory distributions. Some distinct differences between areas are apparent. Area IV has the earliest and narrowest distribution, the steepest upward climb, the highest peak, and the most uniform downward slope. It is the poorest pheasant unit. Area I, with best pheasant populations, has the widest and latest hatching distribution. Areas ranking between these two in quality show a corresponding range of hatching differences.

The 1951 curves for the five areas are shown in Figure 4. Again they reveal definite differences in distribution, with approximately the same characteristics shown by each unit as in 1950. The distinctly flattened top of the Area I curve suggests that more than one distribution may be involved. Examination of the data from each of the six

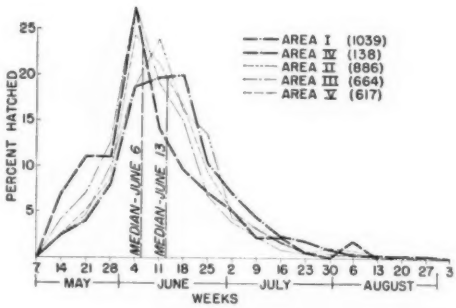

FIG. 4. Pheasant hatching distribution; five areas; 1951.

counties included in Area I disclosed that they fell into two distinct groups. Two counties, Saginaw and Bay, showed a single-peaked, narrow curve with a notch on the downward slope. The four other counties, Huron, St. Clair, Sanilac, and Tuscola, each had a notch or double peak occurring in the same position near the median. The similar distributions were combined into two curves shown in Figure 5.

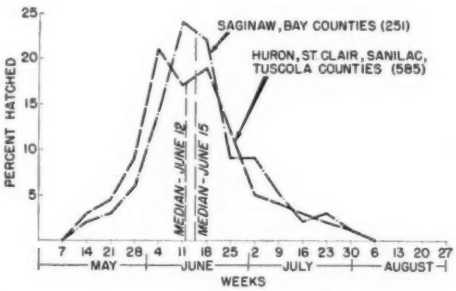

FIG. 5. Pheasant hatching distribution; Area I; 1951.

It seems clear that some factor was operating in the four-county unit to cause the notch at week June 11 and was evidently not affecting the two-county unit. It should be added here that Saginaw and Bay counties are adjacent, are the two westernmost counties

in Area I, and in general are alike in soils and land use. The four other counties form a logical group, similar in land form and agriculture, and they differ to a certain extent from the first two in both these respects.

Pheasant age data from the Prairie Farm, an 8,400-acre study area in central Saginaw County, has afforded opportunity for comparison of a county-wide hatching distribution to one from a relatively small locality within that county. Figure 6 shows the superim-

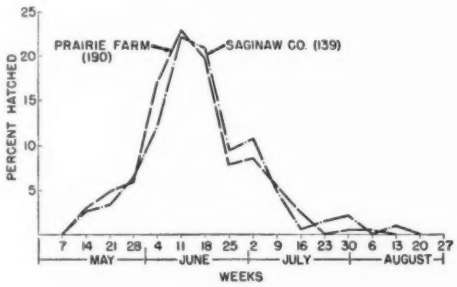

FIG. 6. Pheasant hatching distribution; Saginaw Co. and the Prairie Farm, 1951.

posed curves of the 1951 data from Prairie Farm and from the rest of Saginaw County. It is obvious that they coincide in every important feature, and it can be readily concluded that the hatch and factors affecting it that year were the same on the Prairie Farm as in the rest of Saginaw County. Particularly in evidence are the anomalous notches at week June 25 in both curves. A notch exists at the same point on the curve for Saginaw and Bay counties combined (Figure 5) and on that for Bay County alone; yet it is not present in the remaining four counties of the area, either grouped or taken individually.

A notch of this sort in a hatching curve is rather difficult to account for. It may be caused by a deficit in a certain age class or it may mean that the age class next following has been increased abnormally. For a particular age class to be deficient, an age-selective factor must be postulated—some force must have operated which affected that age class, and no others, at some time after the class came into existence at the onset of incubation. The only apparent selective factors that might so affect chicks or incubating eggs would be weather extremes. MacMullen and Eberhardt (Jour. Wildl. Mgt. **17**: 322–330, 1953) have shown that only the severest of temperature or precipitation extremes causes embryonic mortality. Experiments carried on by Eberhardt (unpublished) indicate that broods show highest vulnerability to rain for the first week or two after hatching, and that even then only a prolonged rainy period accompanied by low temperatures can cause appreciable losses.

Apparently, then, the only agency that could remove a single week's age group from a hatching distribution is a cold, rainy spell within a week or two after hatching. None occurred at this time in 1951, and we may conclude that the distortion in the curves was due to a recurrence of once interrupted nesting effort—in other words, renesting following nest destruction.

Hatching curves for the Prairie Farm from 1949 through 1952 (Figure 7) show a secondary peak occurring each year at about the same time. In both 1949 and 1951 it came at week July 2, in 1950 it was a week later, and in 1952 a week earlier. These recurring anomalies suggest that some nest-destroying factor has been operating at about the same

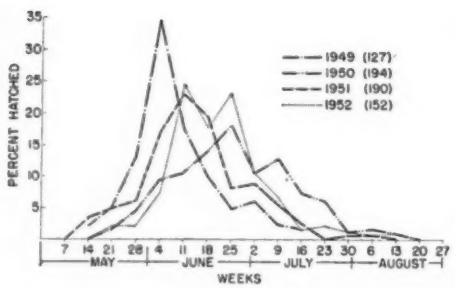

FIG. 7. Pheasant hatching distribution; the Prairie Farm; 1949, 50, 51 and 52.

time each year, probably five or six weeks prior to the resurge in hatching, since it takes at least 35 days for a clutch to be laid and incubated. This would place it in the middle third of May and would throw strong suspicion on some farming practice, probably plowing, as being the responsible agency.

The hatching distributions presented here illustrate the degree of refinement that can be obtained from a state-wide, envelope system of collecting specimens from hunters for age determination. Further refinement probably is not possible, inasmuch as information furnished by hunters on location of kill may not be reliable below a county level. The county groupings, however, have proved sufficient to distinguish some major population differences, and the system will be continued in order that any future population fluctuations can be fully covered.

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A REVIEW OF EXPERIMENTS IN BIOLOGICAL CONTROL OF RABBITS IN AUSTRALIA

Carlton M. Herman

Patuxent Research Refuge, U. S. Fish and Wildlife Service, Laurel, Md.

The European rabbit (*Oryctolagus cuniculus*), common as a wild species in Europe and ancestor of all breeds of laboratory rabbits, was first introduced into Australia around 1860. Its rapid spread on that continent and resulting harmful effects on agriculture and wildlife are well known.

During the past few years Australian investigators have been utilizing a virus infection as a method for controlling rabbits. Since most of the published literature on this subject would not ordinarily come to the attention of North American wildlife technicians, the author was requested to review these publications. References which served as source material for this summary are presented in the bibliography.

When the rabbit first became a serious pest in Australia, rewards were offered for effective ways of exterminating them. Over the years, fumigants, mechanical destruction of warrens, poison, trapping, dogging and driving have been tried with varying success. Occasional droughts and toll by predators have helped limit the rabbit population locally but have not provided lasting relief. It has been surmised that the rabbit population in Australia is between one and three billions.

Biological controls were not overlooked. In the 1880's, Pasteur sent one of his assistants to Australia with *Pasteurella* cultures. He had planned to introduce this organism into the rabbit population. However, cautious government officials vetoed the project. In 1926 a strain of myxoma virus, isolated from a rabbit in Brazil, was sent to New South Wales.

Early work indicated that myxoma virus, the causative agent of a disease called myxomatosis is nearly always lethal to wild and domesticated forms of the European rabbit. It had been demonstrated that all common domesticated animals as well as representatives of the native fauna (mostly marsupials) and the introduced hare (*Lepus europaeus*) were refractory.

Early field trials included tests conducted on an island off the South Australian coast and a dry semi-arid inland area. In both areas mosquitoes were inconspicuous or absent and only very limited spread of the virus occurred. It has been suggested that launching of a large-scale field experiment was delayed because health authorities objected to experimental field studies of the virus except in sparsely populated areas. The importance of mosquitoes as vectors of the disease was not known when initial field tests were made.

World War II caused curtailment of studies on myxomatosis as well as reduction of other types of rabbit control efforts. The rabbit problem became even more acute. In 1949, with the establishment of a Wildlife Section in the Commonwealth Scientific and Industrial Research Organization of Australia (C.S.I.R.O.), extensive ecological studies were initiated to obtain a better understanding of the life history of rabbits and of bionomic factors pertinent to a better basis for biological control.

Field trials with myxoma virus were undertaken on a large scale in 1950, particularly in the Murray-Darling drainage of eastern Australia, in a zone of higher rainfall. Since the belief still prevailed that infection would be spread mainly by contact, tests were made in autumn, winter, and spring. Only a few local outbreaks of infection were observed and at the end of November, 1950, the experiment was considered fruitless. However, in early December * rabbits were reported dying by hundreds along the Murray River flats. This was front page news in Australia. Press releases and processed progress reports issued by the C.S.I.R.O. present a history of the dramatic epizootic which followed.

The first report of a die-off was on the Balldale test site near Corowa, located about seven miles north of the river in New South Wales. However, almost simultaneously, the disease appeared in many other places, some on the Murray mainstream, some on northern tributaries. One of the earliest outbreaks, disclosed in later surveys, was on the Darling River nearly 400 miles from Corowa.

In early January, 1951, the epizootic gathered momentum rapidly. By mid-February myxomatosis had been reported for practically all parts of the huge area, and the peak had passed in most districts. When high mortalities (90 per cent or better) occurred, they were usually achieved within 3 or 4 weeks of the first-noted infection. By

* The Australian summer occurs during the months of December-March.

the end of March, a state of quiescence had been reached.

An obvious feature of the epizootic was close association with rivers, creeks, irrigation systems and swamps, suggesting water-breeding vectors. The myxomatosis map (Fig. 1) for the 1950–

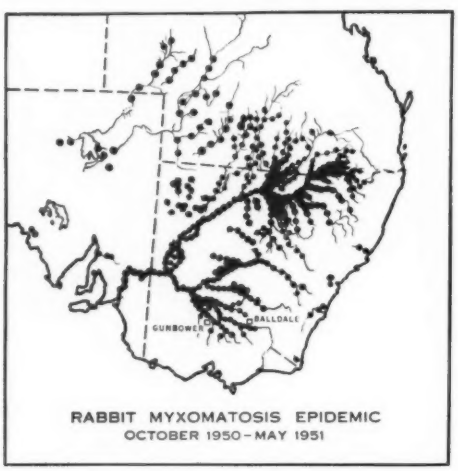

FIG. 1. This map was issued with a press release under date of 4th August 1951, and illustrates the close association of reported outbreaks to the Murray-Darling drainage in southeastern Australia.

1951 summer corresponds closely to the Murray-Darling system. It was estimated that the epizootic covered an area 1,000 miles from north to south and slightly over that from east to west.

Along the Murray mainstream, extensive kills were confined to a very narrow strip often only a few hundred yards wide, except where irrigation complicated the picture. Further north the high mortality belt was wider. In the region lying east and northeast of Bourke on the Darling River, with its complex system of tributary streams, the most spectacular results occurred. It is reported that in places previously swarming with rabbits it was possible to drive for a day or more and see only isolated survivors. Generally, hills set a natural limit to eastward spread, the disease rarely spreading up rivers beyond the plains.

In the following winter, 1951, the disease died down, but in none of the areas studied did it disappear completely. During the following spring, further "seedings" of the virus were accomplished, and a flare-up of cases was again evident in December and months following.

The epizootic of 1951–1952 followed an almost completely different pattern than that of the previous summer. This time it spread over different types of country, most of it away from watercourses, but the kill was considered equally good or better. The delay and partial failure of the monsoon left a substantial part of the epizootic area dry until late summer. The annual rainfall for the area was more normal than the previous wet year.

The main 1951-52 summer epizootic developed over a vast area, extending from the mouth of the Murray in South Australia eastward and then northward inland of the Great Divide. It covered a substantial part of Victoria and the southern two-thirds of the broad belt of undulating country lying between mountains and plains in New South Wales. In some regions, notably the Murray Valley, the epizootic continued in some areas affected during the previous summer, but for the most part outbreaks occurred in new country. Along the Murray River, in 1951–1952, rabbit kill was reported from much greater distances away from possible vector breeding waters than in the previous summer.

During both summers, the epizootic was observed to be most effective in areas of heavy rabbit density. In one survey of 64,000 acres, 20,000 acres were classed as heavily infested with rabbits before the epizootic, but only 640 acres remained in this classification immediately afterward. In many areas, after the outbreak of myxomatosis, the rabbit population was estimated at one-tenth, or less, of 1950 estimates. There has been, so far, no substantial recovery of hardest hit rabbit populations. In some areas, however, rabbits reappeared 4 to 8 weeks after disease activity had ceased. In one closely studied area, a careful estimate gave a 99.5 per cent kill and about 80 per cent of the survivors showed antibodies. It is estimated that between 25 and 50 per cent of the rabbit population in the total area involved in outbreaks may have been destroyed. Continued occurrence of sick rabbits in epizootic areas during winter months indicates that the disease is capable of maintaining itself. It would be difficult to determine to what extent 1951 spring seedings of myxoma virus affected the 1951–1952 summer epizootic and how much of it resulted from natural winter carryover.

Transmission of the virus has been reported as mechanical. Australian investigators have shown that a number of species of blood-sucking arthropods are capable of transmitting the infection. It was found that mosquitoes which had contaminated their mouth parts by feeding on the lesions of myxomatosis-affected rabbits, readily transmitted the infection by bite while mosquitoes which had fed through healthy portions of the skin of sick animals did not. However, infection could be induced when ground-up tissues of such mosquitoes were injected.

Transmission is governed to a large extent by weather conditions and other natural phenomena controlling development and density of vector populations. Aragão had shown that mosquitoes served as vectors in a natural epizootic of the disease in Brazil. Although the widespread dispersal of the virus which produced the epizootic cannot be fully and satisfactorily explained, Australian investigators were convinced that the spread of the disease was a reflection of movements of infected insects, almost certainly mosquitoes.

During the wet summer of 1950–1951, *Culex annulirostris* was considered the dominant mosquito involved in natural spread. For the most part, the area in which the losses occurred coincided with the distribution of this mosquito. Differences in time and amount of rainfall for the summer of 1951–1952, as compared with the previous summer, resulted in habitat changes and altered status of insect vectors. During this second summer it was felt that *Anopheles annulipes* was the chief vector. Intensity of disease activity was, in general, correlated with distribution of suitable breeding grounds of this mosquito, such as vegetated swamps, weedy margins of slow-moving creeks, and waterholes formed by drying up of hill streams. It is a much more adaptable and far-ranging species than *Culex annulirostris*.

In considering future prospects, Burnet (1952) points out that:

> "In myxomatosis, now by human action enzootic among Australian rabbits, we have a unique opportunity to watch the evolution of a 'new' disease. Unless all experience in other fields of epidemiology is inapplicable to this special case,

we can feel certain that the disease will *not* maintain a 99.5 per cent fatality rate. Somehow a *modus vivendi* between the virus and the rabbit will develop.

It is up to us in Australia to follow if we can the process by which, as I expect, the present unstable situation will gradually be replaced by something analogous to the Brazilian position. Already it is being found that there are more immune rabbits to be shot or trapped than there should be. We hear of areas where there was a grade 1 (99 per cent) kill in the first year and only moderate evidence of sick and dead rabbits in the second. Among the still fairly numerous rabbits over 50 percent may be found immune by complement-fixation test on the serum. There are three possibilities: (1) that there are rare gene combinations which confer a significant resistance and that even in the first generation from such survivors there is a sharply increased average resistance; (2) that maternally transmitted antibody may be playing a part. Young born from surviving does might well survive infection and develop lasting active immunity if they were infected before their maternal antibody has fallen to an ineffective level; (3) that mutant strains of virus are appearing which have less power to kill but are equally well distributed by mosquitoes under natural conditions. In all probability such strains would gradually replace the more virulent one, and by immunizing the population render the artificial introduction of virulent virus ineffective.

It will probably take some years before the changes are sufficiently marked to allow a decision as to the relative importance of these three processes. But it is very clear that both for the practical requirement of controlling the rabbit population and for the academic need to understand the development of host-parasite equilibria, we shall have to find the answers to these questions."

The Australian investigators feel confident that myxomatosis will be permanently established as an enzootic infection in the wild rabbit population. Their studies are highly significant, for it is the first time a disease has been successfully applied to reduce the numbers of a wild vertebrate species. Investigators in wildlife management and public health, throughout the world, will be watching with much interest the progress of this study.

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EFFECT OF SIMULATED SNOWSHOE HARE AND DEER DAMAGE ON PLANTED CONIFERS IN THE LAKE STATES [1]

Laurits W. Krefting

U. S. Fish and Wildlife Service [2], St. Paul, Minn.

and

Joseph H. Stoeckeler

Lake States Forest Experiment Station [3]

Snowshoe hares, *Lepus americanus*, and white-tailed deer *Odocoileus virginianus*, often nip off the shoots of young conifers in the Lake States, causing serious damage to tree plantations and natural reproduction. Hares usually do the most damage during their peaks of abundance, when they are often regarded as the "number one" animal pest. Deer, on the other hand, usually fluctuate less in numbers and their browsing pressure is more constant. At times deer may do more damage than hares.

To assess the seriousness of such damage a research project was established. Snowshoe hare and deer damage was simulated by clipping nursery-grown stock of the species and age classes most widely planted in the region. The species used (jack pine, *Pinus banksiana*, red pine, *Pinus resinosa*, white pine, *Pinus strobus*, and white spruce, *Picea glauca*) represent 97 per cent of all trees so far planted in the Lake States (Rudolf, 1950). The three objectives of the study were to determine the effect of clipping on (1) mortality; (2) height growth; and (3) form of the trees.

Review of Literature

In a study of the effect of deer browsing on ponderosa pine and Douglas-fir reproduction in northwestern Montana, Adams (1949) found that because deer prefer ponderosa pine, the more valuable tree, reproduction consists of about one-third pine and two-thirds fir; an inadequate stocking of ponderosa pine. He reported that deer do the greatest damage to pines when they feed on terminal shoots. This type of injury is particularly serious since the loss in height reduces the pine's ability to compete with other trees in the stand.

In a statewide survey of deer damage to forest reproduction in Wisconsin, DeBoer (1947) and Swift (1948) found severe damage to conifers and hardwoods. DeBoer reported 71 per cent of

[1] Acknowledgment is due Shaler E. Aldous of the U. S. Fish and Wildlife Service, who did a large part of the field work. Also, valuable assistance was given by R. H. Gensch and Jack Welch of the U. S. Fish and Wildlife Service; Lucille Olsen and S. R. Gevorkiantz of the Lake States Forest Experiment Station; and G. A. Limstrom, E. E. Aamodt, and G. R. Condit, former members of the station staff.

[2] In cooperation with the Lake States Forest Experiment Station.

[3] Maintained at University Farm, St. Paul, Minnesota by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of Minnesota.

the hardwoods and 52 per cent of the conifers were browsed in central Wisconsin. By contrast, only 18 per cent of the hardwoods and 8 per cent of the conifers were eaten on the Lac du Flambeau Indian Reservation, where unrestricted hunting is permitted. Hares accounted for 9 per cent of the browsing on hardwoods and 5 per cent of that on conifers. Swift (1948) summarized the survey by concluding that the Wisconsin deer herd annually cripples more than 660 million seedlings in the forested area. In the area under forest fire protection, deer damage one out of 5 acres annually while fire damages one out of 500 acres. The ten kinds of trees damaged most, both in number and degree, were: white pine, jack pine, hemlock, white-cedar, sugar maple, aspen, ash, basswood, birch, and oak. Less damage was done to elm, balsam fir, spruce, and red pine. Another Wisconsin deer browse study was made by Arbogast and Heinselman (1950) in the sugar maple, hemlock, and swamp types on the Nicolet National Forest. They found heavy browsing on 96 per cent of the plots.

Adams (1951) also has studied the effect of white-tailed deer browsing on ponderosa pine plantations in northwestern Montana. Seven plots, 1 x 2 rods in size, were planted with ponderosa pine seedlings (1–2 stock) and half of each plot was protected by a deer-proof fence. Twenty-four trees were planted in each half of the plot. Mortality of the unprotected trees was 66 per cent in 1948 and increased to 89 per cent in 1950, while undamaged trees decreased from 12.5 to 1.2 per cent during the same period. Adams concluded that deer are an important factor in the survival of ponderosa pine seedlings.

At an early peak population of snowshoe hares in Minnesota and Wisconsin (1923–1925) Kittredge (1929) reported severe damage to conifer plantations. He found 100 per cent damage to white pine, 78 per cent to white spruce, and 55 per cent to red pine. More than half of the white pine and white spruce had at least 70 per cent of their growth removed. The red pines suffered the least damage as they were planted in an open area, unfavorable as habitat for hares.

Snowshoe hares were very numerous in Minnesota during the next peak population (1932–1935 in many localities) and damage to plantations was severe. The population studies of Green and Evans (1940) showed a peak population of 478 hares per square mile in the Lake Alexander area of Minnesota in 1933. Aldous (1944) made reference to a comparison of damage to red and white pines on the Superior National Forest (Minnesota) as reported by H. L. Shirley in 1932. The red and white pines showed 77 and 75 per cent damage respectively in a brushy location as compared with 19 per cent in an open field. Although the amount of hare damage to plantations depends on the suitability of the area for hares, the extent of the damage also varies by the locality within the Lake States. Rudolf (1950) found that 43 per cent of 55 older Minnesota plantations had hare injury as compared to 10 per cent for 239 older plantations in Michigan, where conditions were less favorable for hares.

In the Allegheny hardwood forest of Pennsylvania (Kane Experimental Forest) Hough (1949) made a study of the effect of deer browsing and hare feeding on the available winter forage. Exclosure studies showed hares caused more dam-

age than deer to low tree and shrub growth. The vegetation protected from deer browsing showed only slight recovery in 5 to 10 years, but the vegetation protected by a deer and hareproof fence had a remarkable recovery.

FIELD WORK

Two clipping experiments were started on the Nicolet National Forest in northeastern Wisconsin—one on the Eagle River District; the other at the Hugo Sauer Nursery. The "forest" experiment was started in the spring of 1941 to determine the effect of clipping the terminal shoot of jack pine (1–0 and 2–0 stock) and red pine (2–0 and 2–1 stock) by single and repeated cuttings. All of the test trees were clipped one inch below the end of the terminal bud in the dormant season. No lateral branches were clipped. The treatment given was typical of deer and hare nippings observed on recently established tree plantations. One test group of trees was clipped once; other groups were clipped once each year for two and three years in succession. A fourth group was clipped once, allowed one year of rest without clipping, and clipped again the following year.

The experimental area was divided into 4 subplots, each containing one duplication of each treatment for each class of stock planted. For each of the 4 classes of stock there were 10 treatments, each repeated 4 times. The seedlings were planted at 5-foot intervals in furrowed rows 250 feet long and 6 feet apart. All told, there were 160 rows of 50 trees each or 8,000 trees used in the experiment. Half of the clipping was begun in 1941. On another duplication, clipping was started in 1942. For statistical purposes, the four lots of 100 trees in each clipping frequency and age class were combined. The entire study area was enclosed in a rabbit-proof fence. The effectiveness of the fence was systematically checked.

The "nursery" experiment was started in the fall of 1942. White pine (2–0 and 2–1 stock), white spruce (2–2 stock), and red pine (2–0 stock) were planted at 6-inch intervals in rows 75 feet long and 1-foot apart. For each species and age class tested there were 2 rows of trees. The test groups of 25 trees each (6 groups per row) were repeated twice for white pine and white spruce and four times for red pine. For statistical purposes the tests for the trees clipped twice in succession were combined. In all, 1,200 trees were used in the study. All the trees were clipped in the same manner as the forest experiment, and were similarly protected with a rabbit-proof fence.

RESULTS

FOREST EXPERIMENT. The first half of the experiment was started in the spring of 1941 and the second half in the spring of 1942. Field checks were made either before or after the growing season from 1942 to 1946. Only the last or sixth year data are reported here.

The survival data (Table 1) show that jack pine is more resistant than red pine to mortality from clipping. For all clipping frequencies combined, jack pine suffered a loss of only 5 per cent as compared to 13 per cent for red pine.

Jack pine did not decrease in survival regularly or consistently with an increased frequency of clipping, and the differences between the control trees

TABLE 1.—SIXTH YEAR FIELD SURVIVAL (PER CENT) OF JACK PINE AND RED PINE [1]

Treatment	Jack Pine			Red Pine		
	1–0	2–0	Average	2–0	2–1	Average
Check (no clipping)	82.2	86.5	84.4	89.5	82.5	86.0
Clipped once						
S'41, S'42	82.0	80.0	81.0	72.2[xx]	82.0	77.1[xx]
Clipped twice						
S'41, S'42 [2]	70.0	84.8	77.4	69.0[xx]	79.0	74.0[xx]
S'42, F'42						
Clipped three times						
S'41, S'42, F'43	74.5	86.5	80.5	66.0[xx]	69.2[xx]	67.6[xx]
S'42, F'42, F'43						
Clipped twice in alternate years						
S'41, F'42	75.0	84.5	79.8	74.0[xx]	74.0[xx]	74.0[xx]
S'42, F'43						

[1] Based on 4 duplications of 50 trees each, in each of two separate tests, started 1941 and 1942 respectively.

[xx] Significantly poorer than checks at 1 per cent level.

[2] S and F refer to clipping done in the spring and fall.

and the clipped trees were not significant. Red pine survival, however, was reduced consistently and very significantly; the losses for both age classes combined being 9, 12, and 18 per cent respectively for 1, 2, and 3 years of clipping. Mortality was especially great for 2–0 red pine, differences between the controls and the clipped treatments were 17, 21, and 24 per cent respectively for 1, 2, and 3 clippings.

Differences in the survival of the two age classes of red pine were also noted. The 2–0 trees had a significant loss in survival with only a single clipping while the 2–1 stock showed only slight variations of .5 per cent and 3.5 per cent respectively for the trees clipped once and those clipped twice in successive years. Mortality was not significant for 2–1 red pine until the trees were clipped three times and twice in alternate years. The striking difference in survival between the two age classes of red pine for a single clipping may be attributed in part to the fact that fewer needles were left on the 2–0 age class as compared to the older 2–1 trees.

The height growth data (Table 2) show that clipping has a greater effect on red pine than on jack pine. For all clipping frequencies combined, jack pine had only 9 per cent reduction in height compared to 25 per cent for red pine. After three successive clippings red pine showed a height growth reduction of 36 per cent as contrasted with 13 per cent for jack pine. Red pine also exhibited a consistent reduction in height with increased frequency of clipping but jack pine did not follow this pattern.

The difference in the ability of jack pine and red pine to withstand clipping can be attributed to the more rapid juvenile growth habit of jack pine, and especially the ability of the species to produce occasional internodal branches. In contrast, the branching on red pine

TABLE 2.—SIXTH YEAR HEIGHT, IN FEET, OF JACK PINE AND RED PINE [1]

	Jack Pine			Red Pine		
	1–0	2–0	Average	2–0	2–1	Average
Check (no clipping)	4.8	5.7	5.3	2.6	3.0	2.8
Clipped once	4.8	5.0[xx]	4.9[x]	2.0[xx]	2.5[xx]	2.3[xx]
Clipped twice	4.5[x]	5.4[x]	5.0[x]	1.8[xx]	2.1[xx]	2.0[xx]
Clipped three times	4.3[xx]	4.9[xx]	4.6[xx]	1.6[xx]	1.9[xx]	1.8[xx]
Clipped twice in alternate years	4.3[xx]	5.2[xx]	4.7[xx]	1.9[xx]	2.2[xx]	2.1[xx]

[1] Based on 4 duplications of 50 trees each.
[x] Significantly poorer than check at 5 per cent level.
[xx] Significantly poorer than check at 1 per cent level.

is strictly from the nodes although under some conditions red pine, like other pines, may develop an adventitious bud along the leader. After it is clipped, the old leader dies back to the next node or a new leader may form from a specially developed bud. Jack pine is better able to withstand clipping because the new leader may develop from an internodal branch with little delay.

NURSERY EXPERIMENT. The clipping experiment at the Hugo Sauer Nursery began in October 1942. Field checks were made before or after the growing season from 1943 to 1947. Only the last or sixth year data are reported here. Although the survival averages for all duplicated experiments shown in Table 3 show increasing mortality losses with increasing severity of clipping, the data were quite erratic within duplicates and analysis indicates no significant differences between the controls and the clipping treatments. The survival of white spruce 2–2 stock was better for all treatments than the white pine 2–0 and 2–1 stock or the red pine 2–0 stock.

The height growth data (Table 4) show that the red and white pines are affected by clipping to a greater extent than white spruce. White pine (2–0) clipped once showed no significant loss but the trees clipped twice, three times, and twice in alternate years were significantly poorer than the control trees. For all the clipping frequencies combined red pine (2–0) showed a height difference of 27 per cent as compared to 7 per cent for white spruce and 26 and 14 per cent respectively for white pine (2–0 and 2–1). After three clippings in succession, white pine showed a height growth reduction of 39 per cent and 26 per cent for the 2–0 and 2–1 stock while it was only 7 per cent for the white spruce (2–2). It is important to note that the data for 2–1 white pine are significant only for the trees clipped three times in succession. For white spruce the reductions in height were very slight and were not statistically significant. For red pine the losses in height due to clipping were significant. The group of trees clipped once at planting time showed a height difference of 20 per cent while the group given one year of rest before clipping had a difference of 35 per cent.

The study shows that white pine is more resistant to clipping than red pine although both species are much alike in

TABLE 3.—SIXTH YEAR NURSERY SURVIVAL (PER CENT) OF WHITE PINE WHITE SPRUCE, AND RED PINE [1]

Treatment	White Pine[2]			White Spruce[2]	Red Pine[3]
	2–0 Stock	2–1 Stock	Average	2–2 Stock	2–0 Stock
Check (no clipping)	84	92	88	98	86
Clipped once F'42[4]	74	88	81	92	71
Clipped once F'43	..	..	..	..	82
Clipped twice F'42, F'43 F'43, F'44	78	87	82	91	..
Clipped three times F'42, F'43, F'44	58	78	68	88	..
Clipped twice in alternate years F'42, F'44	62	82	72	98	..

[1] There is no significant difference in survival by the various treatments.
[2] Based on 2 duplications of 25 trees each.
[3] Based on 4 duplications of 25 trees each.
[4] F refers to clipping done in the fall.

their growth habits. After clipping, white pine is capable of producing a new leader from one of the branches at the node or from an adventitious bud formed on the leader. The forest test on red pine (2–0 and 2–1 stock) showed that clipping significantly affects mortality and height growth. In contrast, the results of the white pine nursery test (2–0 and 2–1 stock) revealed that clipping has a significant effect on height growth and no effect on survival. The 2–0 white pine stock was not influenced by the clipping until the trees were clipped two and three times in succession and the 2–1 stock was not affected until it was clipped three years in a row. White pine grew at a faster rate than red pine and the difference in growth may reflect the ability of white pine to form new leaders in a shorter length of time.

White spruce had the most resistance to the clipping treatments of all the species tested. There was no effect on either mortality or height loss because of clipping. The ability of white spruce to withstand clipping may be attributed to the good scattering of internodal buds along the leader. After clipping, a new leader soon develops from the internodal bud nearest the point of clipping and as a result there is little loss in height.

EFFECT ON FORM OF TREES. In spite of single or repeated clippings, none of the trees became multiple-stemmed. All of the conifers tested have that advantage over broadleaf trees which often become, and sometimes remain, multiple-stemmed because of deer or hare damage in early life. No apparent effect on the form of the trees was noted and this finding can be attributed to the ability of the conifers tested to produce new leaders very soon after clipping.

TABLE 4.—SIXTH YEAR HEIGHT, IN FEET, OF WHITE PINE, WHITE SPRUCE, AND RED PINE

Treatment	Date of Clipping	White Pine[1]		White Spruce[1]	Red Pine[2]
		2–0	2–1	2–2	2–0
Check (no clipping)	....	3.1	4.2	2.7	5.1
Clipped once	F'42[3]	2.7	3.8	2.7	4.1[xx]
Clipped once	F'43	...	...	...	3.3[xx]
Clipped twice	F'42, F'43				
	F'43, F'44	2.3[xx]	3.9	2.6	...
Clipped three times	F'42, F'43, F'44	1.9[xx]	3.1[xx]	2.5	...
Clipped twice in alternate years	F'42, F'44	2.2[xx]	3.8	2.4	...

[1] Based on 2 duplications of 25 trees each.
[2] Based on 4 duplications of 25 trees each.
[3] F refers to clipping done in the fall.
[xx] Significantly poorer than the check trees at the 1 per cent level.

DISCUSSION

The clipping experiment, which was designed to simulate snowshoe hare and deer nipping of conifers commonly planted in the Lake States, has shown that the removal of one inch of the terminal growth by single or repeated clippings reduces survival and height growth of planted stock. Ability to withstand damage varied by species and can be attributed to the inherent ability of each species to produce new leaders. The species tested ranked as follows in order of sensitivity to clipping: red pine, white pine, jack pine, and white spruce. Larger classes of stock were injured less than smaller ones by clipping. In general, it may be concluded that clipping had a greater effect on height growth than on mortality. Also, clipping exerted more effect on survival of small trees than on larger trees because a larger percentage of the leaf area was removed. However, loss in height on the surviving trees is of equal importance and these findings have a practical application. Retarding the growth by clipping the terminal shoot reduces the tree's potential ability to survive or to maintain a dominant position in the stand.

SUMMARY

1. Jack pine, red pine, white pine, and white spruce planting stock was clipped to simulate snowshoe hare and deer damage to recently established tree plantations in the Lake States. Some test groups were clipped once, some were clipped twice or three times in succession; others were clipped once and allowed a year of rest before being clipped again. Age classes represented were: 1–0 and 2–0 jack pine, 2–0 and 2–1 red pine; 2–0 and 2–1 white pine; and 2–2 white spruce.

2. Jack pine was much more resistant to clipping mortality than red pine. This difference may be attributed to the ability of jack pine to form a new leader from an internodal bud and to its more rapid juvenile growth. Jack pine ranked third in sensitivity to clipping.

3. Red pine was the most sensitive to the clipping treatments. Survival and height losses were especially great for

the 2–0 stock and there were significant differences in the 2–1 age class. Red pine usually develops a new leader from the nodes but it may form a new leader from an adventitious bud.

4. White pine was second in sensitivity to the treatments. It was less sensitive than red pine because it is able to produce a new leader sooner. Seedlings of the 2–0 age class showed no regular drop in survival with the intensity of clipping, although a fairly consistent pattern was shown for the trees of the 2–1 age class. Clipping reduced the height of both age classes.

5. White spruce was the lowest in sensitivity to clipping. The species was not affected by clipping the leader because it has a good scattering of internodal buds capable of developing a new leader. In contrast, the pines usually die back to the next node.

6. For the species tested, the effect of clipping on survival and height growth varied a great deal by age classes. Height growth losses were usually much greater than survival differences. In the forest, loss of height is very important since it reduces the tree's ability to compete with others in the stand. Mortality is of equal importance and is greatest when the trees are small.

7. The clipping treatments had no apparent effect on the form of the trees, since none became multiple-stemmed.

8. The practical application of the findings is that the older age classes of planting stock, especially the transplant trees, should be used where white-tailed deer and snowshoe hare damage may occur, because they can better withstand browsing. Also browse-tolerant species should be selected where the problem is serious.

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RACIAL INVESTIGATIONS OF THE STRIPED BASS, *Roccus saxatilis* (WALBAUM)

Edward C. Raney and Donald P. de Sylva

Department of Conservation, Cornell University, Ithaca, N. Y.

The striped bass, *Roccus saxatilis* (Walbaum), is an important sport and commercial fish found along Atlantic and eastern Gulf coasts. Introduced into Pacific waters in the last quarter of the nineteenth century, it has thrived and is now present in California and Oregon. It is anadromous, spawning in the lower reaches of large rivers. The most important Atlantic spawning grounds seem to be the Roanoke River, several large rivers tributary to Chesapeake Bay, the lower Delaware and the Hudson. The striped bass is also migratory, moving northward along the Atlantic coast in spring, apparently not for the purpose of spawning, and southward in fall. During migration it moves in large schools and it is at this time that it is often taken in numbers by fishermen. Studies on its migrations on the Atlantic coast have been reported by Merriman (1937 and 1941) and these data as well as other information on its life history have been recently summarized by Raney (1952).

A knowledge of the source of the stock or stocks which make up the schools of large striped bass is vital for conservation administrators and fishery biologists. It appears that those bass two years old and older undertake coastwise migrations. Merriman (1941), Tiller (1950) and Vladykov and Wallace (1952) believed that most of the basic migratory stock was produced in the Chesapeake Bay region. This conclusion was based on results of tagging, and upon the observation that a rapid increase in the catch in northern waters from New Jersey to New England coincided with the production of a large year class in Chesapeake Bay. This seemed to be true for the rather extensively studied 1934 and 1940 year classes. For an extended period before 1934 the Atlantic stocks of striped bass were low but they have increased and at present are relatively high.

An attempt was made by Merriman (1941: 47) to determine the origin of striped bass stocks by measurements of the first and second years' growth on the scale; growth presumably made during a non-migratory period. He showed that striped bass which spawned in 1935 in Carrituck Sound, N. C. grew faster during the second summer than those of the 1934 year class taken in Chesapeake Bay, at Montauk, New York, at Harkness Point, Conn. and in Cape Cod Bay. He also points out the fallacy of comparing the growth of bass from different year classes. Also using scales, Tiller (1950: 12) studied the growth rate during the first two years of life of striped bass of the 1940 year class which were obtained in 1942 from Chesapeake Bay and Long Island and showed that there was a remarkable similarity in growth. Tiller interprets these data as confirming results obtained by tagging bass as evidence of Chesapeake origin of the stocks. It is possible however

that two stocks of fishes might differ genetically, even on a rather high level of differentiation in one or several characters, and still be virtually identical in their scale growth.

Both Merriman (1941) and Vladykov and Wallace (1952) pointed out the difficulty of accurately counting fin rays of striped bass in the field. The latter gave some data and pointed out some differences in the mean values of the dorsal and anal fin ray counts from several localities in Chesapeake Bay. Unfortunately they gave only mean figures for these counts and their data are not as useful as they might have been had frequency distributions been included.

PROBLEM

The problem of the present study was to determine by study of fin ray counts in young, if the striped bass in the Chesapeake Bay system and in the Hudson River are differentiated, and if so, to determine the level of differentiation which has been reached. The constancy of characters from year to year was also investigated for the Hudson River.

The investigation was begun when adequate numbers of young striped bass of the 1949 year class were available from the Hudson River and from the Pamunkey River, a tributary of Chesapeake Bay. Samples of other populations preserved in museum collections have been studied but the size of these is inadequate in many cases. It is unfortunate that so little material on the striped bass has been properly preserved, and it would seem to be axiomatic that all students of fishery biology should deposit adequate samples of their specimens in the U. S. National Museum or other repository.

This study is offered as a preliminary report. It is hoped that adequate series of young striped bass collected from many localities and at various times will be made available so that the situation along the entire Atlantic coast may be fully and continuously appraised. Virtually all specimens of striped bass in this study were young of the year from 3 to 10 cm. in standard length; a few were small juveniles.

ACKNOWLEDGMENTS

We wish to thank those who have made material available. The specimens from Cos Cob, Conn. are deposited in the Bingham Oceanographic Collection, Yale University and were loaned by the director, Daniel Merriman. The fine collection of ten series from the Hudson made during 1949 were obtained through John R. Greeley and Cecil Heacox of the New York State Conservation Department. Additional specimens taken in the Hudson River in 1950, by the U. S. Fish and Wildlife Service shad survey, were forwarded by Clinton Atkinson and G. B. Talbot. We are especially indebted to William H. Massmann, Virginia Fisheries Laboratory for the numerous series collected during the summer of 1949 in the Pamunkey River. The specimens from the Chickahominy River in 1949 were collected by Neil D. Richmond, Carnegie Museum, and the senior author. A. J. Calhoun of the Division of Fish and Game, California, kindly collected specimens especially for this study during January, 1952. Others collected by him in 1947 were loaned to us from the California Academy of Sciences through the kindness of the curator, W. I. Follett. The many miscellaneous specimens from Chesapeake Bay were collected mostly by William C. Schroeder, are deposited in the U. S. National Museum and were made available by the curator, Leonard P. Schultz. Richard E. Tiller, Maryland Department of Research and Education, has assisted us in locating various places in the Chesapeake Bay region. The present studies are being extended as specimens become available by Albert G.

Mehring, Cornell University graduate student, with the assistance of a fellowship from the Sport Fishing Institute. He has kindly made available some of his findings for report here.

From February to June, 1953, the senior writer was engaged by the U. S. Fish and Wildlife Service as coordinator of the Striped Bass Research Program. This afforded opportunity to examine specimens of striped bass and the data which were obtained confirm the results of the racial analysis presented herein. Time was also available for an analysis of returns from the Schaefer-Salt Water Sportsman tagging program and the basic conclusions of this study are included in this paper.

MATERIAL EXAMINED

Abbreviations used for collections: C.U., Cornell University; U.S.N.M., United States National Museum.

Connecticut: Mianus R. at outlet of Cos Cob Power Plant, May 29–June 5, 1949, 44 spec. Bingham Ocean. Coll., Yale Univ.

New York, Hudson River:

1936, Haverstraw, Aug. 25, 30 spec., C.U. 5180.

1949, Athens, Aug. 16, C.U. 15465, 23 spec.; Port Ewen, Aug. 5, 4 spec., C.U. 15464 and Aug. 26, 12 spec., C.U. 18215.

Poughkeepsie, Aug. 31, 8 spec., C.U. 20541. Haverstraw and Stony Point, July 22, 17 spec., C.U. 15466; Aug. 5, 36 spec., C.U. 15463; Aug. 19, 6 spec., C.U. 15467; Aug. 26, 21 spec., C.U. 18221; Sept. 2, 15 spec., C.U. 18222; Sept. 13, 13 spec., C.U. 18219.

1950, Catskill to Piermont, Sept. and Oct., 57 spec., C.U. 21069–21076.

New Jersey: Navesink River at Red Bank, Aug. 1882, 2 spec., U.S.N.M. 31524.

Chesapeake Bay and tributary rivers:

Localities north of the mouth of the Potomac River: Md.: Chesterton, Aug. 1910, 4 spec., U.S.N.M. 67023; Havre de Grace, May 8–10, 1922, 4 spec., U.S.N.M. 90810; Bay Ridge, July 19, 1936, 1 spec., U.S.N.M. 102171; Annapolis, Aug. 19, 1921, 2 spec., U.S.N.M. 90801; Grove Pt., Aug. 31, 1921, 12 spec., U.S.N.M. 90813; Patuxent R., Aug. 1934, 2 spec., U.S.N.M. 93809; Solomons, Aug. 10, 1921, 9 spec., U.S.N.M. 90807; Aug. 11–12, 1921, 20 spec., U.S.N.M. 90808; July 15, 1949, 2 spec., C.U. 14224 and one specimen from vicinity of Solomons, no date, C.U., not catalogued.

Potomac River System:

D.C., South of Chain Bridge, June 11, 1921, 1 spec., U.S.N.M. 85405 and Bennings Br., Nov. 10, 1910, 1 spec., U.S.N.M. 70342.

Md., Lanedon, July 27, 1929, 5 spec., U.S.N.M. 92377.

Va., Coan R., Aug. 6, 1921, 33 spec., U.S.N.M. 90818; Blackistone Island, Oct. 20, 1921, 2 spec., U.S.N.M. 90805; Lewisetta, Aug. 5, 1921, 2 spec., U.S.N.M. 90819; Bryans Pt., Nov. 10–11, 1911, 2 spec., U.S.N.M. 85733; Liverpool Pt., Nov. 27–28, 1911, 1 spec., U.S.N.M. 83925.

Rappahannock River System:

Va., Rappahannock R., July 25–Aug. 1, 1921, 4 spec., U.S.N.M. 90815 and Oct. 15–16, 1921, 3 spec., U.S.N.M. 90814.

York River System:

Lower York, Va., July 8–12, 1921, 5 spec., U.S.N.M. 90817; Gloucester Pt. Sound, Aug. 7, 1949, 2 spec., C.U. 14422.

Pamunkey River, 1949: Hillis Reach, July 28, 13 spec., C.U. 14856 and Aug. 21, 1 spec., C.U. 14383; Sweet Hall Landing, July 12, 15 spec., C.U. 14898; Aug. 4, 2 spec., C.U. 14426; Aug. 11, 9 spec., C.U. 14455 and C.U. 14466; Aug. 17, 4 spec., C.U. 14395; Aug. 31, 8 spec., C.U. 14579 and 14568; Cohoke Marsh, July 12, 1 spec., C.U. 14939; Cumberland Thorofare, July 7, 1 spec., C.U. 14916; Mussel Pond Reach, Aug. 4, 11 spec., C.U. 14666; Mill Reach, Aug. 11, 1 spec., C.U. 14441; Lister Manor, June 28, 2 spec., C.U. 14945; July 7, 2 spec., C.U. 14923; Aug. 4, 1 spec., C.U. 14483; Rockahock Reach, July 28, 3 spec., C.U. 14864; Reservation Reach, July 12, 2 spec., C.U. 15046; Gregorys Reach, July 12, 1 spec., C.U. 14936; Putney's Mill, July 12, 1 spec., C.U. 14933.

James River System:

Va., Fortress Munroe, Sept. 16, 1897, 1 spec., U.S.N.M. 69764; James R. at Treasure Id. Beach, June 27, 11 spec., C.U. 16779; Chickahominy R. at Richmond's Farm, June 26, 21 spec., C.U. 16747.

California, San Joaquin River near West Island, July 10, 1947, 35 spec., Calif. Acad. Sci. and 4 mi. West of Antioch, Jan. 4, 1952, 62 spec., C.U. 20724.

METHODS

Counts of the dorsal, anal, and pectoral fins are included in this study. We hope that the collection of additional large specimens will make possible the future investigation of possible differentiation in scale counts. Fin rays were enumerated in the manner prescribed by Hubbs and Lagler (1949: 10). The last two fin-ray bases in both the dorsal and anal fins were counted as one. For the pectoral fins, all the rays including the rudiments were counted. The counts were made by the junior author after preliminary trial and agreement on the method of counting.

RESULTS

The spines in dorsal and anal fins showed little variation in more than 600 specimens counted. All variants were from different collections and localities. The first dorsal had 9 spines except in four variants, where one had 8 and three had 10. The second dorsal fin constantly had one spine. The anal fin had 3 spines except for a single specimen which had 2.

Frequency distributions of dorsal, anal, and pectoral fin soft ray counts indicate differences between the Hudson River samples on the one hand and the Chesapeake Bay samples on the other, the latter usually being higher. The results are given in Tables 1–4 and are presented in part in Figs. 1–3 using an adaptation of the method of Hubbs and Perlmutter (1942: 582) which enables one to judge the significance of the differences at a glance. In each of the horizontal figures, the range of variation is indicated by the solid bottom line, the mean is represented by the single vertical line, one standard deviation on either side of the mean is marked by the hollow rectangle, and twice the standard error on either side of the mean is indicated by the solid rectangle. The number of specimens in the sample is given at the right. Considerable reliance can be placed on the significance of the difference between samples if the corresponding black rectangles are only slightly separated or if the overlap is not more than a third of the length of the shorter of the two black rectangles.

DORSAL RAYS

The dorsal fin soft rays are relatively variable in samples within and between drainage systems. In large samples, those from the Hudson are usually much lower than Chesapeake samples. The count was usually 11 or 12, and 10 occurred often in Hudson samples; the extreme range was 9 to 14 rays. When small samples of 15 or fewer specimens collected in 1949 from several localities in the Pamunkey River or from the same locality but taken at different times were compared in Table 1, there was considerable variation in the mean values as well as percentage separable when a line is drawn between 11 and 12 rays. The mean values varied from 11.4 to 11.9 whereas the mean of 89 specimens taken in 1949 was 11.6.

The same type of irregular variation, although over a small range, was noted of dorsal soft ray counts in Hudson River samples. Table 1 shows that samples collected in 1949 varied from a mean of 10.3 to 11.2 in samples of 8 to 36 specimens taken at several localities and at the same locality but at different times (though apparently of the same stock). A mean of 11.0 was obtained from 155 specimens counted for the entire Hudson system for the year 1949

TABLE 1.—NUMBER OF DORSAL SOFT RAYS IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 11 OR FEWER DORSAL SOFT RAYS

Locality	Collections		Number of dorsal rays								
	Date of	Number of	9	10	11	12	13	14	No.	Mean	%
Conn., Mianus R., Cos Cob	1949	1	..	3	23	18	..	..	44	11.3	59
N.Y., Hudson R.	1936–50	19	2	22	147	70	..	1	242	11.2	71
Catskill to Piermont	1950	8	..	..	37	20	..	..	57	11.4	65
All localities	1949	10	2	22	100	30	..	1	155	11.0	80
Athens	Aug. 16	1	1	5	14	3	..	..	23	10.9	87
Port Ewen	Aug. 5 & 26	2	..	2	10	4	..	..	16	11.1	75
Poughkeepsie	Aug. 31	1	..	2	5	1	..	..	8	10.9	88
Haverstraw & Stony Point	July 22	1	..	2	12	3	..	..	17	11.1	82
" " " "	Aug. 5	1	..	4	25	7	..	..	36	11.1	81
" " " "	Aug. 26	1	1	5	10	4	..	1	21	10.3	76
" " " "	Sept. 2	1	..	1	12	2	..	..	15	11.1	87
" " " "	Sept. 13	1	..	..	11	2	..	..	13	11.2	85
Haverstraw	Aug. 25, 1936	1	..	..	10	20	..	..	30	11.7	33
N.J., Navesink R.	1882	1	..	..	..	2	..	..	2	....	..
Chesapeake Bay System	1897–1949	26	..	3	86	145	2	1	237	11.6	38
Bay N. of Potomac R.	1910–34	11	..	..	19	36	..	..	55	11.7	35
Patuxent R.	1921–48	4	..	..	14	18	..	..	32	11.6	44
Potomac River system	1910–21	6	..	1	16	30	..	..	47	11.6	36
Coan R.	1921	1	..	1	12	20	..	..	33	11.6	39
Rappahannock R.	1921	2	..	..	4	3	..	..	7	11.4	59
York River System	1921–49	23	..	..	28	66	1	..	95	11.7	30
Lower York	1921–49	2	..	..	2	5	..	..	7	11.7	29
Pamunkey R.	1949	21	..	..	26	61	1	..	88	11.6	30
Reservation Beach	July 7	1	..	..	5	5	..	..	10	11.5	50
Hills Reach	July 28	1	..	..	4	9	..	..	13	11.7	31
Mussel Pond Reach	Aug. 4	1	..	..	5	5	..	..	10	11.5	50
Sweet Hall Landing	July 12	1	..	..	2	13	..	..	15	11.9	13
" " "	Aug. 11	1	..	..	5	3	..	..	8	11.4	63
" " "	Aug. 31	1	..	..	1	6	..	..	7	11.9	14
James River System	1897–1949	3	..	2	19	10	1	1	33	11.4	64
James R.	1897–1949	2	..	..	6	6	..	..	12	11.5	50
Chickahominy R.	1949	1	..	2	13	4	1	1	21	11.3	71
Calif., San Joaquin R.	1947–52	2	..	1	24	71	..	..	96	11.7	26
San Joaquin R.	1947	1	..	..	10	25	..	..	35	11.7	29
San Joaquin R.	1952	1	..	..	14	46	..	..	61	11.7	25

and 11.4 for 57 specimens taken in 1950. A high mean of 11.7 was obtained for 30 specimens taken in 1936 in the Hudson. A line drawn between 11 and 12 dorsal rays permits a separation of 67% of the 1936 Hudson sample from 80% and 65% of the 1949 and 1950 Hudson samples respectively. The 1936 Hudson sample also was high in anal count, and for both dorsal and anal ray counts, compared closely to the Chesapeake Bay samples from various localities and which represent several year classes. Indeed, the 1936 sample is so much like the Chesapeake Bay specimens in this regard and if dorsal rays alone are considered it seems almost as if they had resulted from the same spawning stock or, if only slightly different genetically, had been similarly influenced by the water temperature and other conditions which perhaps affect the development of the phenotype. In this connection it is of interest to note that the James River samples averaged low for dorsal ray counts and closely approached Hudson River samples except for that of 1936.

Drawing a line between 11 and 12 dorsal rays best separates the two racial

groups involved. It permits a separation of 62% of all Chesapeake specimens (12 or more dorsal rays) from 71% of all Hudson specimens (1936, 1949, and 1950) and from 76% of the specimens collected in 1949 and 1950. Disregarding the 1936 Hudson collection and following the method of Ginsburg (1938) we have what may be considered a level of differentiation at a subspecific or high racial level. However the temporal and geographical inconsistencies (high dorsal value for the single available 1936 Hudson collection and the low value for the James River samples) make such a consideration untenable.

At first glance it might seem that the individuals of the 1936 Hudson sample resulted from the spawning of bass which had moved to the Hudson from Chesapeake Bay where the anal ray count is high. However, the pectoral rays which seem to be the best single character for separating the Hudson from Chesapeake stocks is low for the 1936 Hudson sample and the pectoral character contributes considerable weight to the character index (Table 4).

Of interest are the dorsal ray values for two California samples taken during 1947 and 1952; mean 11.7 in each (Table 1). These are comparable to dorsal counts of 12 rays obtained for two specimens of young striped bass taken in 1882 in the Navesink River, New Jersey, the source of specimens introduced into California. Also 74% of California specimens had 12 dorsal soft rays. These values are closer to those obtained for Chesapeake Bay and Delaware populations than for the geographically closer Hudson stocks.

In summary, although the dorsal ray counts of samples were more variable than the anal or pectoral rays they seem to be of some value especially when considered along with other counts.

ANAL RAYS

The anal soft ray count was also variable. The counts of fish from the Hudson were low (1936 sample excepted) in comparison with Chesapeake Bay. The mode was 11 rays, and 10 rays occurred often. Occasionally 9 occurred in Hudson samples and 12 was counted in the Chesapeake samples.

Table 2 includes a comparison of anal counts from several small samples from the Pamunkey River. The range was 10 to 12 and the means varied from 10.7 to 11.0 for samples of 7 to 15 specimens. The results were similar when river systems tributary to Chesapeake Bay were compared; the range was 10 to 12 anal rays with small differences in the means (10.7 to 10.9), and the mean for the grand total of all 239 specimens was 10.9. The values for James River samples lie consistently near the lower values.

The anal counts for samples, many of them small, from the Hudson (Table 2) are fairly stable with a range of 9 to 11 rays and mean values ranging from 10.3 to 10.7 in samples taken during 1949. For 1949 the maximum and minimum mean values were obtained from samples taken at different times in one area (between Haverstraw and Stony Point). Paralleling the high value for dorsal rays obtained at Haverstraw in 1936 was a large value for anal rays; mean 10.8 for 30 specimens (Table 2). This value was considerably larger than that obtained for composite samples from the Hudson taken in 1949 or 1950. It was also higher than the Connecticut collection of 1949

TABLE 2.—NUMBER OF ANAL SOFT RAYS IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 10 OR FEWER ANAL SOFT RAYS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN TABLE 1.

Locality	Date	Number of anal rays						
		9	10	11	12	No.	Mean	%
Conn., Mianus R., Cos Cob	1949	..	13	31	..	44	10.7	30
N.Y., Hudson River	1936–50	6	102	134	..	242	10.5	45
Catskill to Piermont	1950	..	25	32	..	57	10.6	44
All localities	1949	6	72	77	..	155	10.5	50
Athens	Aug. 16	1	12	10	..	23	10.4	57
Port Ewen	Aug. 5 & 26	..	6	10	..	16	10.6	38
Poughkeepsie	Aug. 31	..	4	4	..	8	10.5	50
Haverstraw & Stony Point	July 22	..	7	10	..	17	10.6	41
" " " "	Aug. 5	1	20	15	..	36	10.4	58
" " " "	Aug. 26	2	10	9	..	21	10.3	57
" " " "	Sept. 2	2	5	8	..	15	10.4	47
" " " "	Sept. 13	..	4	9	..	13	10.7	31
Haverstraw	Aug. 25, 1936	..	5	25	..	30	10.8	20
N.J., Navesink R.	1882	..	..	2	..	2	..	..
Chesapeake Bay System	1897–1949	..	39	198	2	239	10.9	16
Bay N. of Potomac R.	1910–34	..	8	47	..	55	10.9	15
Patuxent River	1921–48	..	6	26	..	32	10.8	19
Potomac River System	1910–21	..	5	42	..	47	10.9	11
Coan R.	1921	..	3	30	..	33	10.9	9
Rappahannock River	1921	..	2	5	..	7	10.7	29
York River System	1921–49	..	14	81	1	96	10.9	15
Lower York	1921–49	..	1	6	..	7	10.9	14
Pamunkey River	1949	..	13	75	1	89	10.9	15
Reservation Beach	July 7	..	3	8	..	11	10.7	27
Hills Reach	July 28	..	1	12	..	13	10.9	8
Mussel Pond Reach	Aug. 4	..	2	8	1	11	10.9	18
Sweet Hall Landing	July 12	..	2	13	..	15	10.9	13
" " "	Aug. 11	..	1	7	..	8	10.9	13
" " "	Aug. 31	..	..	7	..	7	11.0	0
James River System	1897–1949	..	10	23	..	33	10.7	30
James R.	1897–1949	..	4	8	..	12	10.7	33
Chickahominy R.	1949	..	6	15	..	21	10.7	29
Calif., San Joaquin R.	1947–52	1	15	80	..	96	10.8	17
San Joaquin R.	1947	..	1	34	..	35	11.0	3
San Joaquin R.	1952	1	14	46	..	61	10.7	25

and the James River system samples of 1949.

When the anal ray count of the Chesapeake population as a whole was compared with the Hudson River total, the same trends were noted as with dorsal and pectoral rays (higher in the Chesapeake). A line drawn between 10 and 11 anal rays will separate 45% of all Hudson specimens (low values) from 84% of all Chesapeake specimens (high values). Omitting the 1936 Hudson sample gives a greater degree of separation; 49% are separated from 84% of all Chesapeake specimens; an average separation of 66%. The percentages of separation by river systems are given in Table 2.

When considering anal rays alone in comparing the total Hudson sample with that from the Chesapeake, a racial (level below a subspecies) level of differentiation has been reached (Ginsburg, 1938). However, as in the case with dorsal rays, the inconsistency of the 1936 Hudson sample and the 1949 James River samples, prevents designation of these populations as races. Nevertheless,

TABLE 3.—NUMBER OF PECTORAL RAYS (BOTH SIDES) IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE PERCENTAGE OF SPECIMENS WITH 32 OR FEWER PECTORAL RAYS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN TABLE 1

Locality	Date	Number of pectoral rays														
		28	29	30	31	32	33	34	35	36	37	No.	Mean	S.D.	S.E.	%
Conn., Mianus R., Cos Cob	1949	..	..	1	..	21	12	10	..	..	..	44	32.7	1.13	.17	50
N.Y., Hudson R.	1936–50	1	2	15	28	108	41	40	1	..	..	236	32.2	1.19	.08	65
Catskill to Piermont	1950	..	1	3	6	22	9	12	1	..	..	54	32.4	1.32	.19	58
All localities	1949	1	1	11	19	71	25	24	..	..	..	152	32.2	1.17	.10	68
Athens	Aug. 16	1	1	3	6	7	2	1	..	..	..	21	31.3	..	..	86
Port Ewen	Aug. 5 & 26	..	..	1	1	8	1	5	..	..	..	16	32.5	..	..	64
Poughkeepsie	Aug. 31	..	..	1	2	2	2	1	..	..	..	8	32.0	..	..	63
Haverstraw & Stony Pt.	July 22	..	..	..	1	10	3	3	..	..	..	17	32.5	..	..	65
" " " "	Aug. 5	..	..	1	6	14	5	9	..	..	..	35	32.4	..	..	60
" " " "	Aug. 26	..	..	1	1	12	4	3	..	..	..	21	32.3	..	..	67
" " " "	Sept. 2	..	..	1	2	7	4	1	..	..	..	15	32.1	..	..	67
" " " "	Sept. 13	..	..	2	..	7	3	1	..	..	..	13	32.1	..	..	69
Haverstraw	Aug. 25, 1936	..	..	1	3	15	7	4	..	..	..	30	32.3	1.00	.18	63
N.J., Navesink R.	1882	..	..	..	..	..	..	2	..	..	..	2	..	..	..	0
Chesapeake Bay System	1897–1949	..	..	1	4	19	43	120	28	14	2	231	33.9	1.08	.07	10
Bay N. of Potomac R.	1910–34	..	..	1	..	6	6	28	10	4	..	55	33.9	1.15	.15	13
Patuxent R.	1921–48	..	..	1	..	7	5	14	4	1	..	32	33.5	1.31	.23	25
Potomac River System	1910–21	..	..	..	..	5	16	21	4	1	..	47	33.6	1.04	.15	11
Coan R.	1921	..	..	..	..	2	12	15	3	1	..	33	33.7	1.07	.19	6
Rappahannock River	1921	..	..	..	1	..	..	5	..	1	..	7	33.9	1.60	.60	14
York River System	1921–49	..	..	..	..	4	15	50	11	8	1	89	34.1	0.97	.10	5
Lower York	1921–49	..	..	..	..	..	2	5	..	..	..	7	33.7	0.84	.32	0
Pamunkey R.	1949	..	..	..	..	4	13	45	11	8	1	82	34.1	1.00	.11	5
Reservation Beach	July 7	..	..	..	..	..	1	6	1	..	..	8	34.0	..	..	0
Hills Reach	July 28	..	..	..	..	2	..	7	1	..	..	10	33.7	..	..	20
Mussel Pond Reach	Aug. 4	..	..	..	..	..	1	5	3	1	..	10	34.4	..	..	0
Sweet Hall Landing	July 12	..	..	..	..	2	1	9	..	3	..	15	34.1	..	..	13
" " "	Aug. 11	..	..	..	..	..	1	5	1	1	..	8	34.3	..	..	0
" " "	Aug. 31	..	..	..	..	..	2	2	1	1	1	7	34.6	..	..	0
James River System	1897–1949	..	..	..	3	4	6	16	3	..	1	33	33.5	1.36	.24	21
James R.	1897–1949	..	..	..	..	1	2	7	2	..	..	12	33.8	1.15	.33	8
Chickahominy R.	1949	..	..	..	3	3	4	9	1	..	1	21	33.3	1.45	.32	29
Calif., San Joaquin R.	1947–52	..	..	..	2	14	19	59	1	1	..	96	33.5	0.99	.10	17
San Joaquin R.	1947	..	..	..	..	5	7	22	1	..	..	35	33.5	0.94	.16	14
San Joaquin R.	1952	..	..	..	2	9	12	37	..	1	..	61	33.4	1.07	.14	18

the anal count is useful when considered with other characters.

The California samples line up closely with the Chesapeake mean for anal counts.

PECTORAL RAYS

The pectoral ray counts gave the best separation (of any single character) and varied in the same general way as the dorsal and anal counts; higher in the Chesapeake than in the Hudson. Since there was some variation in the counts when the left and right pectoral of a specimen were compared, the total count of both sides was used. Since the number is usually the same on either side with 34 and 32 being the most common values, the frequency distributions are less regular than those for the dorsal and anal counts.

The variability of the pectoral ray count in small samples and from system to system are given by frequency distributions in Table 3 and are plotted in Fig. 1. In the various samples from the

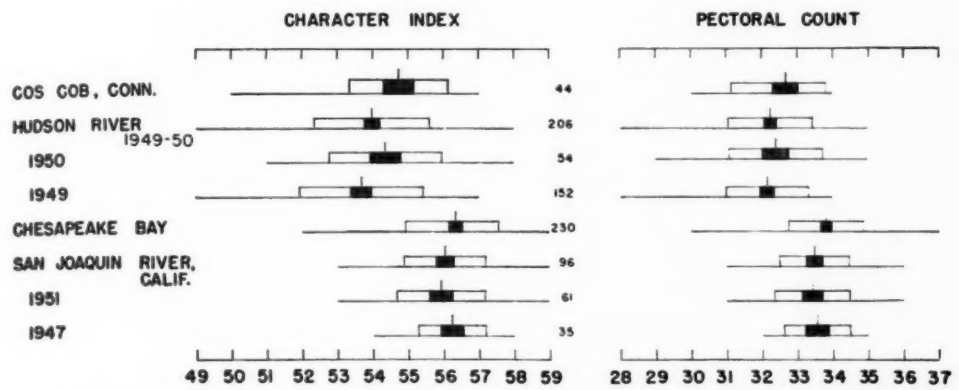

FIG. 1. Character indices (sum of counts of dorsal; anal; and pectoral, both sides, soft rays) and of pectoral soft rays (both sides) for samples of young striped bass from several river systems along the Atlantic coast and from California. The frequency distributions for the counts are given in Tables 3 and 4. The dates indicate the year class of the sample including the California sample which was from the 1951 year class but which was collected January 4, 1952. Method of representation of data adapted from Hubbs and Perlmutter (1942: 582). See text for explanation.

Pamunkey River the pectoral count was usually 34, with a range of 32 to 37; the means of the samples varied from 33.7 to 34.6 as compared to a mean of 34.1 for the total sample from the Pamunkey River system. For the several other river systems tributary to Chesapeake Bay the pectoral count was also usually 34, range 30–37; the mean values varied from 33.3 to 34.1 with a mean of 33.9 for all Chesapeake specimens.

In samples from the Hudson River the pectoral count was usually 32 with a range of 28 to 35. The means of several small samples shown in Table 3 ranged from 31.3 to 32.5 with a mean of 32.2 for all Hudson specimens. It is interesting to note that the 1936 sample from the Hudson had a low mean pectoral count of 32.3 which is in line with other Hudson samples, and contrary to the trends for dorsal and anal ray counts of this sample. The Cos Cob, Connecticut sample is higher in pectoral counts than Hudson samples but is still lower than Chesapeake values.

A good separation between Hudson and Chesapeake samples is obtained when a line is drawn between 32 and 33 pectoral rays (Table 3). It permits a separation of 63%, 68% and 58% of Hudson specimens (low values) collected respectively in the years 1936, 1949 and 1950 from a very high percentage of those taken in the several systems tributary to Chesapeake Bay as follows: North of Potomac River, 87%; Potomac River, 89%; Pamunkey River, 95%; James River 79%; and total Chesapeake Bay drainage system 90%. In pectoral as well as dorsal and anal counts the James River system was low.

The California samples line up with those from Chesapeake Bay and 83% had counts of 33 or more pectoral rays; this is in line with trends shown in counts of other fins.

Upon inspection of the percentage of separation values given in Table 3 it is ob-

TABLE 4.—FREQUENCY DISTRIBUTIONS OF THE CHARACTER INDEX (SUM OF SOFT RAYS OF DORSAL, ANAL AND BOTH PECTORAL FINS) IN YOUNG AND YEARLING STRIPED BASS. THE LAST COLUMN (%) GIVES THE NUMBER OF SPECIMENS WITH AN INDEX OF 55 OR LESS. THE NUMBER OF COLLECTIONS FROM EACH LOCALITY IS THE SAME AS GIVEN IN TABLE 1.

Locality	Date	Character Index															
		49	50	51	52	53	54	55	56	57	58	59	No.	Mean	S.D.	S.E.	%
Conn., Mianus R., Cos Cob	1949	..	1	..	1	5	10	15	8	4	..	..	44	54.7	1.40	.21	73
N.Y., Hudson River	1936–50	1	4	12	25	42	64	52	18	17	1	..	236	54.0	1.64	.11	85
Catskill to Piermont	1950	..	..	1	4	11	17	10	3	7	1	..	54	54.4	1.59	.22	80
All localities	1949	1	4	11	19	29	42	28	11	7	..	..	152	53.7	1.78	.14	88
Athens	Aug. 16	1	3	3	2	5	3	4	..	..	..	..	21	52.5	1.91	.42	100
Port Ewen	Aug. 5 & 26	..	..	..	2	3	7	..	1	3	..	..	16	54.3	1.62	.41	75
Poughkeepsie	Aug. 31	..	1	1	1	..	2	2	1	..	..	..	8	53.4	2.03	.71	88
Haverstraw & Stony Pt.	July 22	..	..	..	1	5	5	4	1	1	..	..	17	54.1	1.24	.30	88
" " " "	Aug. 5	..	..	2	4	7	11	6	4	1	..	..	35	53.9	1.68	.17	86
" " " "	Aug. 26	..	..	4	3	3	3	4	2	2	..	..	21	53.7	2.05	.45	81
" " " "	Sept. 2	..	..	..	3	5	4	1	2	..	..	..	15	53.6	1.39	.36	87
" " " "	Sept. 13	..	..	1	1	1	5	5	..	..	..	..	13	53.9	1.52	.42	100
Haverstraw	Aug. 25, 1936	..	..	..	2	2	5	14	4	3	..	..	30	54.8	1.50	.27	77
N.J., Navesink R.	1882	..	..	..	..	..	..	..	..	2	..	..	2	..	..	..	0
Chesapeake Bay System	1897–1949	..	..	..	3	4	15	31	64	79	20	14	230	56.3	1.41	.09	23
Bay N. of Potomac R.	1916–34	..	..	..	..	3	4	7	8	22	8	3	55	56.4	1.54	.21	26
Patuxent R.	1921–48	..	..	..	..	3	4	6	6	10	2	1	32	55.8	1.54	.27	41
Potomac River System	1910–21	..	..	..	..	..	6	7	15	16	2	1	47	56.1	1.16	.17	28
Coan R.	1921	..	..	..	..	..	4	4	11	12	1	1	33	56.2	1.17	.20	24
Rappahannock R.	1921	..	..	..	1	..	..	..	4	1	..	1	7	56.0	1.93	.73	14
York River System	1921–49	..	..	..	..	..	1	10	27	33	9	8	88	56.7	1.33	.14	13
Lower York	1921–49	..	..	..	..	..	..	1	3	3	..	..	7	56.3	0.76	.29	14
Pamunkey R.	1949	..	..	..	..	..	1	9	24	30	9	8	81	56.8	1.37	.15	12
Reservation Beach	July 7	..	..	..	..	..	..	2	1	3	1	..	7	56.4	..	..	29
Hills Reach	July 28	..	..	..	..	..	1	1	1	6	1	..	10	56.5	..	..	20
Mussel Pond Reach	Aug. 4	..	..	..	..	..	..	1	3	2	3	1	10	57.0	..	..	10
Sweet Hall Landing	July 12	..	..	..	..	..	..	2	5	5	..	3	15	56.8	..	..	13
" " "	Aug. 11	..	..	..	..	..	..	1	3	3	1	..	8	56.5	..	..	13
" " "	Aug. 31	..	..	..	..	..	..	..	2	2	1	2	7	57.4	..	..	0
James River System	1897–1949	..	..	..	2	1	4	7	10	7	1	1	33	55.6	1.64	.29	42
James R.	1897–1949	..	..	..	..	..	2	2	3	4	1	..	12	56.0	1.22	.35	33
Chickahominy R.	1949	..	..	..	2	1	2	5	7	3	..	1	21	55.3	1.68	.37	48
Calif., San Joaquin R.	1947–52	..	..	..	..	3	8	17	26	40	1	1	96	56.0	1.16	.12	29
San Joaquin R.	1947	..	..	..	..	..	1	8	9	16	1	..	35	56.2	0.96	.16	26
San Joaquin R.	1952	..	..	..	..	3	7	9	17	24	..	1	61	55.9	1.26	.16	31

vious that we are dealing with two populations within each of which some subracial variation seems to occur. If the overall separation of Hudson vs. Chesapeake is considered it is possible to separate 72.5% of the specimens on pectoral counts alone. This percentage is close enough to allow allocations to subspecific rank if the criteria of Ginsburg (1938: 261) are accepted. To do so without a knowledge of the variation characteristics of other Atlantic Coast populations would be futile.

CHARACTER INDEX

As a practical and useful device to obtain the maximum separation of the two stocks which are involved when comparing the Hudson with the Chesapeake striped bass, we have constructed a character index obtained by adding the soft rays of the dorsal, anal and pectoral (both sides) fins for each speci-

men. Such an index has been obtained for each system and for several samples within some drainages and are shown in Table 4 and are portrayed graphically in Figures 1 to 3. The mean of the index for each sample within a system is fairly constant even when the samples are small. Table 4 indicates the slight variation from place to place and from the same locality collected at several times from the Pamunkey River system. When comparing adjacent drainages such as the James and the York River (Fig. 2) there are significant differences

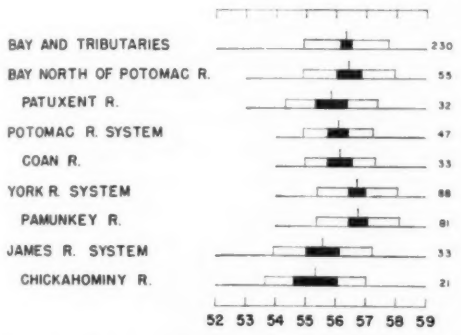

FIG. 2. Character indices (sum of dorsal, anal and pectoral fin soft rays) of samples of young or small juvenile striped bass from Chesapeake Bay and its tributaries. The frequency distributions are given in Table 4.

between the means of the character index for each and it would seem that there is not completely free gene exchange between these two stocks and it is obvious that they are differentiated on a relatively low level (subrace). A line drawn between 56 and 57 in the character index distribution (Table 4) separates 73% of the James River specimens (low) from 56% of the York system specimens (high); average separation is 64.5%. In this connection it should be noted from Figure 2 that the Potomac River samples, and the Chesapeake stocks taken from north of the Potomac River mouth, occupy intermediate positions (between James and York) as far as their character indices are concerned, although not geographically intermediate between the James and York. Much is yet to be learned about the differences which exist in stocks of the same species in these large tributaries of Chesapeake Bay. Recent studies (see Massmann, Ladd and McCutcheon, 1952, and Raney and Massmann, in press) especially on the Pamunkey, Mattaponi and Rappahannock rivers indicate that there are great differences in abundance of many species and these most likely reflect fundamental differences in the habitats. A knowledge of whether the above mentioned differences between the striped bass population of the James and Pamunkey rivers are genetic, as we expect they are, depends on results of further studies now under way.

It may be seen that in several samples from the Hudson River (Fig. 3) it is possible to get significant differences in samples of young fish taken at different localities during the same year. Also the composite samples for several years may differ significantly (considering significance in the usually accepted statistical sense). The sample from the most upstream locality at Athens, New York, was extreme (low) in this regard. No upstream cline was noted. The variation in numbers of fin rays from year to year may fluctuate with the water temperature during larval development. The lowest counts in the Hudson were obtained in 1949 during which time the average daily water temperature was higher during April and May

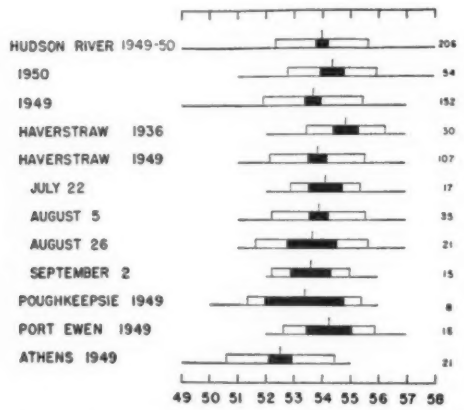

FIG. 3. Character indices (sum of dorsal, anal and pectoral soft fin rays) for Hudson River samples of young striped bass. Samples are shown for several year classes, for the same year class taken at several localities, and for samples from one locality taken at various times from July to September. The frequency distributions of the various counts are given in Table 4. The samples listed as Haverstraw, 1949, were taken along shore between Haverstraw and Stony Point.

(records of Poughkeepsie Water Works) than the water temperature taken over the same period in 1936 and 1950. Perhaps there are several subracial groups within the Hudson, some sedentary and others migratory. Future research may furnish the answer to these questions.

The usefulness of the character index is apparent when the percentage of specimens which may be separated is noted in Table 4. The percentage of specimens from the Hudson River which have 55 or fewer counts is 85% compared to 77% of all Chesapeake Bay specimens which have 56 or higher counts; an average separation of 81%. These percentages vary somewhat although not greatly from year to year in the Hudson River being 77% in 1936, 88% in 1949 and 80% in 1950. The Connecticut specimens were similar to the Hudson stock and had 73% with 55 or fewer counts. Incomplete investigations now under way indicate that northern populations (St. Lawrence River, Nova Scotia and New Brunswick) are high in character index counts and compare well with the Chesapeake samples. California bass line up rather well with Chesapeake stocks (mean 56.3) and compares closely with the two Navesink River, New Jersey specimens which have a high character index (57).

CONCLUSIONS AND SUMMARY

It was possible to separate a high percentage of the individuals of most samples which originated in the Hudson River from those spawned in the several tributaries of Chesapeake Bay. The most consistent and maximum separation was obtained by a character index which was made by adding the counts of the dorsal, anal and pectoral (both sides) soft rays. The Hudson River specimens have the lower values.

Of the single characters, the pectoral counts are the most consistent geographically and give the best degree of separation of all samples of the two populations. The dorsal rays seem to vary in a more erratic manner from place to place and year to year than either anal or pectoral rays and therefore are less useful in separating these populations. However, they show the same trend and contribute significantly to the character index especially when specimens of the same year class are compared.

In any one river system such as the Hudson River there may be significant variations from year to year in any of

the characters investigated. These fluctuations may be caused by differences in water temperature and perhaps other factors during larval life at the time when the fin ray number is determined. The assumption is made that fin rays numbers are genetically fixed within narrow limits and that the minor fluctuations which occur from year to year due to different physical and perhaps chemical conditions at any one locality or differences in time of spawning, will tend to balance out when samples are taken over a period of several years.

Some substantiation for the validity of this assumption of relative constancy of fin ray counts is indicated by counts on the California samples. Little, if any, change has taken place in the characters under investigation, in California specimens, although precise fin counts of the original introduced stock are not and never will be available. Present California stocks resulted from plants made in 1879 and 1882 from young bass taken in the Navesink and Shrewsbury rivers, New Jersey, localities geographically close to the Hudson River (see Smith, 1896: 449, for an account of the introduction). Two specimens of young striped bass collected in the Navesink River in 1882 were available. In dorsal (12 rays), anal (11 rays), pectoral (34 rays) counts and character index (57) these specimens fit well when compared to the two recently collected California samples. No recent young specimens of striped bass seem to be available from the Navesink River and vicinity. However, study by Albert G. Mehring of recent material from the Delaware River indicates that the Delaware stock is close to the Chesapeake samples and judging from the counts given above the early New Jersey stock is presumed to have belonged to the same race.

Further evidence of the fixity of fin ray numbers is that from a study of the 1921 sample taken in the Coan River (Table 2, Fig. 3). The results are very close to those obtained from large samples taken in adjacent areas at different times including relatively recent material.

Evidence is fast accumulating to prove that the observed differences between the Hudson and Chesapeake samples are not segments taken from a north-south cline.

The degree of differentiation which has been reached between the two main populations is not now deemed worthy of nomenclatorial recognition as subspecies although we predict that further investigations of future year classes from these and other areas will show them to be good races (sense of Ginsburg, 1938) which might well be referred to as the Hudson race and the Chesapeake-Delaware race.

The presence of one race (or subspecies?), the Hudson race, located in the center of the migratory range of another race (or subspecies?), the Chesapeake-Delaware race, some segment of which migrates north to Rhode Island and Massachusetts, calls for explanation. A study now underway by the senior author, of tag returns of striped bass mostly under 16 inches in total length, from the Schaefer-Salt Water Sportsman tagging program, carried on from 1949 to 1952, reveals that in the late spring the Hudson race, or a portion thereof, regularly moves to the western end of Long Island Sound. These bass seldom go eastward beyond Fairport, Connecticut or Northport, Long Island.

Some also migrate out the mouth of the Hudson River but do not often go farther east along the south shore of Long Island than Jones Beach. In the fall there is a reverse movement into the Hudson River where they are found in goodly numbers as far upstream as Stony Point. The striped bass of the Chesapeake race migrate independently and strike off the New Jersey shore and the south shore of Long Island where concentrations are known at points such as Montauk. From here they move almost directly north to such well known bass areas as Niantic, Connecticut, Point Judith, Rhode Island and northward. During the fall southern migration it seems that a relatively few individuals of the Chesapeake Bay race get into the western end of Long Island Sound and a few enter the mouth of the Hudson River. Most make their way en masse southward to the Delaware and Chesapeake Bays (Merriman, 1937 and 1941).

Within the Chesapeake Bay the James population is low (perhaps a good subrace), the Pamunkey stock is high, and the Potomac and more northern Bay samples are somewhat intermediate in counts which indicate a degree of differentiation of rather low level.

The possibility that two or more subraces may inhabit the Hudson and perhaps other rivers should be investigated. A stock is known and fished in the vicinity of Athens, New York. The evidence from meristic characters (Fig. 3) indicates it may be a sedentary population. Also of interest is the negative evidence that no striped bass tagged in Long Island Sound or elsewhere has been recovered from a point on the Hudson closer than Hyde Park (only one return), a distance of more than 35 miles downstream. A few other returns came from Peekskill and Verplanck, a distance of 70 miles downstream from Athens.

Not easily explained is the approach to Chesapeake stocks made by the 1936 Hudson samples in anal and dorsal counts although this stock is similar to 1949 and 1950 Hudson samples in pectoral ray counts. Perhaps the 1936 Hudson sample contained young which resulted from parents of dual origin.

If additional counts of other year classes indicate similar differences in races (Hudson River vs. Chesapeake Bay-Delaware River) one might be able to identify the origin of the bass making up the large migratory schools which move along the Atlantic coast in spring and fall. Counts on a sample of 20 to 25 should give a character index which could easily be compared visually with Figure 1. This is based on the assumption, which in the light of our present knowledge seems warranted, that Chesapeake Bay and the Hudson River are the sources for most of the middle Atlantic and New England striped bass stock at the present time.

Preliminary investigations of other Atlantic stocks indicate that the same counts (dorsal, anal, and pectoral) and various character indices drawn from these counts will make possible the identification of most if not all the several populations which seem to exist.

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USE OF HERBICIDES FOR ESTABLISHING FOOD PATCHES [1]

K. C. Hamilton and K. P. Buchholtz

Dept. of Agronomy, Univ. of Wisconsin, Madison, Wisconsin

Within the past decade the use of herbicides for the control of weeds has become a valuable technique in the production of many agronomic crops. To be of value the herbicide must give the desired control of weeds without significant injury to the crop. Herbicides are usually used as a supplement to cultivation and are intended to give only temporary control of annual weeds. Under some conditions herbicides will control weeds for extended periods and production of a profitable crop without cultivation may be possible.

To determine the possible value of herbicides for establishing food patches for upland game birds, a series of experiments were conducted during 1951 and 1952 by the Wisconsin Agricultural Experiment Station. The cost of cultiva-

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tion is an important consideration where small, widely separated food patches are established. In this study, all cultivation on treated plots was replaced by a single treatment with an herbicide applied at, or shortly after planting time. After the seed bed of the food patch had been prepared, planted, and treated with an herbicide, it was left undisturbed for the remainder of the growing season. It was expected that certain treatments might allow the crops to develop without severe competition from weeds.

The lack of cultivation and incomplete control by an herbicide may allow some weedy growth late in the season. If this growth occurs without significantly reducing the production of the planted crop, the food patch will have, in addition to the crop, a stand of weeds providing desirable food and cover. The type of weed growth would depend on the chemical used, the rate of application, the time of application, the weed seeds present in the soil, and environmental factors, such as rainfall and temperature.

This paper is a report on some of the more interesting results obtained on chemically treated plots.

METHODS AND MATERIALS

The plots in both years were located on well drained Miami silt loam soil of medium fertility near Madison. The seed beds was prepared shortly before crops were planted. Although the soil contained an ample supply of weed seeds, the area was sown with rape, mustard, millet, and ryegrass to assure an abundant weedy growth. Both experiments contained 18 plots that received treatment with herbicides, as well as untreated cultivated and uncultivated check plots. All were duplicated four times in a randomized complete block design.

The 1951 experiment was a screening trial of six crops sprayed pre-emergence with six chemicals at three rates each. The crops (Wisconsin hybrid corn 416, Hawkeye soybeans, Norghum sorghum, dwarf sunflower, safflower, and buckwheat) were planted May 25 in rows seven feet long spaced three feet apart.

The chemicals tested were TCA (sodium salt of trichloroacetic acid) applied at 4, 8, and 12 pounds per acre, CMU (3-(p-chlorophenyl)-1, 1-dimethylurea) at 1, 2, and 4 pounds, endothal (3, 6-endoxohexahydrophthalate) at 2, 4, and 8 pounds, DN (an amine salt of dinitro-o-sec-butyl phenol) at 8, 12 and 16 pounds, CIPC (chloro isopropyl-(3 chlorophenol) carbamate) at 8, 12, and 16 pounds, and 2,4-D (alkyl ester of 2,4-dichlorophenoxyacetic acid) at 1, 2, and 4 pounds. The chemicals were applied in water equivalent to 40 gallons per acre on May 28 with a bicycle sprayer.

The 1952 experiment was designed to obtain an additional year's data on promising chemical treatments and to secure information on the effect of date of chemical application. The crops, Wisconsin hybrid corn 416AA and Monroe soybeans, were planted May 25. Each plot contained three rows spaced 30 inches apart and 25 feet long. One row was planted to corn, one to soybeans, and one was left unplanted to allow room for spray overlap of adjacent treatments.

The chemicals used in the 1952 trial were CMU applied at 1 and 2 pounds per acre, CIPC at 4 and 8 pounds, and DN at 6 and 12 pounds. All were applied

in water equivalent to 40 gallons per acre with a bicycle sprayer. The first set of plots was sprayed pre-emergence on May 26. The second set was sprayed June 5 just as crops and weeds were emerging. The last set was sprayed post-emergence on June 12 when the crops were three to four inches high.

Crop seedling stands, grass and broad-leaved weed stands, and crop yields were measured in both years. The data obtained were statistically analyzed. Data on crop development, plant cover, weed species present, and amount of weed seed were also obtained. The seed yield of weeds in September was calculated by determining the average weight per seed head from a sample of several hundred heads, and counting the number of heads of each weed in 12, one-foot quadrats in each treatment. Estimations of weed seed yields obtained by this method are lower than actual weed seed production because at the time of sampling some seed was immature while some had already shattered.

RESULTS

1951 EXPERIMENT. The data on weed and crop stands and corn yields from the plots treated with the middle rate of each chemical used in the 1951 screening trial are shown in Table 1.

Weed stands. TCA was the only chemical which did not reduce significantly the seedling stands of broad-leaved weeds. Despite the reduction of broad-leaved weeds on the plots treated with endothal, the plots treated with TCA, and the uncultivated check plots, the growth of mustard on them became so dominant that the plots were mowed to prevent the mustard from maturing seed. All chemical treatments reduced the initial stands of grassy weeds compared to those on the uncultivated check plots. However, later control of weeds was poor on plots treated with 2,4-D and endothal. Although a chemical application may cause a statistically significant reduction in the initial weed infestation, competition from the remaining stand may still reduce crop yields.

TABLE 1.—CROP AND WEED STANDS AND CORN YIELDS FROM THE 1951 SCREENING TRIAL

Herbicide	CMU	DN	CIPC	TCA	Endothal	2,4-D	Untreated Checks	
Lbs./A.	2	12	12	8	4	2	Cult.	Not Cult.
Weed stands	June 20 (plants per 8 square feet)							
Broad-leaved	1*	1*	14*	113	52*	4*	...	101
Grasses	1*	7*	4*	2*	48	19*	...	61
Crop stands	June 20 (plants per 25 foot of row)							
Corn	48	40	36	35*	47	43	47	...
Soybean	48*	50*	76*	71*	44*	25*	109	...
Sunflower	6*	2*	83	67	12*	2*	65	...
Safflower	7*	0*	52	48	26*	3*	62	...
Buckwheat	7*	0*	9*	92	34*	106	102	...
Sorghum	12*	3*	3*	14	35	2*	32	...
Crop yields	(bushel per acre)							
Corn	90	107	57*	...	...	45*	94	...

* Difference from check exceeding the 5% LSD.

Crop stands. The data on crop stands show that there was a great variation in the tolerance of the crops to the pre-emergence application of chemicals. The higher rates of chemical treatment gave greater reductions in plant stands. The seedling stands of the crop plants were not an accurate indication of crop yield at maturity. While the stand of corn on plots treated with CIPC and 2,4-D did not differ significantly from the stand on the check plots, corn yields on these plots were reduced significantly.

Crop yields. The only yield measurements taken were those of corn. Yields were not obtained on the mowed plots. The data obtained shows that the yields of plots treated with CMU and DN equaled those of the cultivated untreated check plots. The calculated yield figures based on a single row are probably higher than would be obtained from multiple row plots.

Weed cover. The plots treated with the lower rates of CMU had a scattered stand of yellow foxtail (*Setaria lutescens*) and barnyard grass (*Echinochloa crus-galli*). Plots treated with the higher application of CMU were bare except for the corn as shown in Figure 1, A. Figure 1, C shows that the plots treated with CIPC had a dense stand of ragweed (*Ambrosia artimisiifolia*). These plots yielded seed up to 400 pounds per acre. The plots treated with DN had dense stands of yellow foxtail and barnyard grass. Cover on plots treated with 2,4-D was a thick stand of mixed weeds. Cover on the plots treated

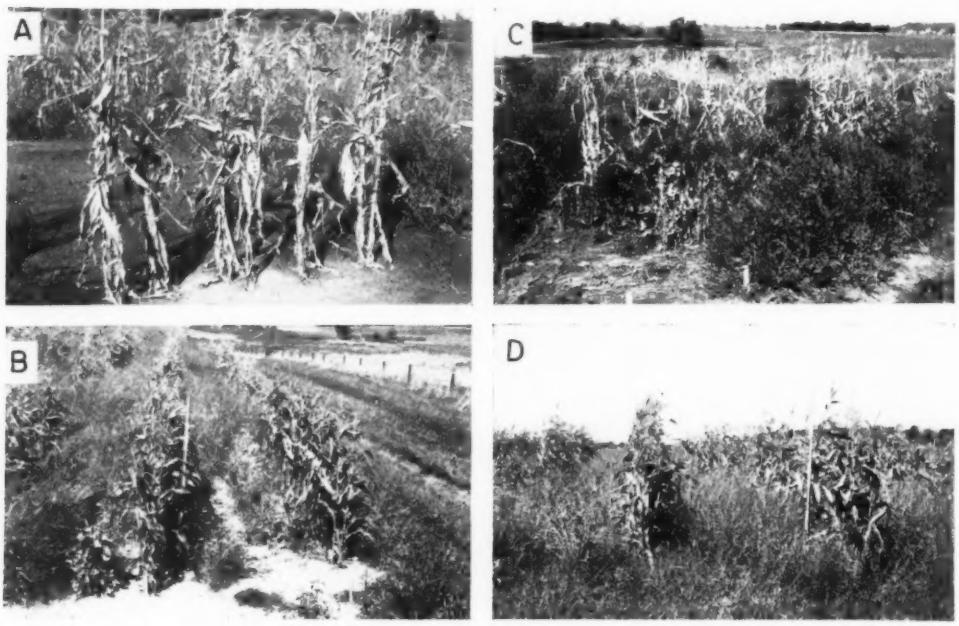

FIG. 1. Plots sprayed pre-emergence with: A. CMU at 4 pounds per acre giving complete control of weeds. B. CMU at 1 pound (right) and 2 pounds per acre (left), allowing scattered stands of yellow foxtail. C. CIPC at 8 pounds per acre allowing a dense stand of ragweed. D. DN at 12 pounds per acre (right) allowing a dense stand of yellow foxtail. Cultivated check (left).

with TCA and endothal was a dense growth of mustard.

1952 EXPERIMENT. The data on corn and soybean stands and yields and weed stands, yields and cover from plots treated pre-emergence and post-emergence with the higher rate of DN, CIPC and CMU are shown in Table 2.

Crop stands. The only chemical treatment reducing the stand of corn was the post-emergence application of DN at 12 pounds per acre. All applications of CMU and DN, except the 6 pound pre-emergence treatment of DN, caused a reduction of soybean stands.

Crop yields. Yields of corn on the plots sprayed with CIPC, the 1-pound pre-emergence application of CMU, and the 6-pound pre-emergence and 12-pound post-emergence application of DN were significantly less than those of the cultivated check plots. The average corn yields on plots treated with CMU equaled those on the cultivated check plots. All corn yields were based on a 7.5-foot spacing between rows. Yields would be higher had the rows been spaced normally. Soybean yields, however, are calculated on the basis of a 30-inch row. While the yields of soybeans from all chemically treated plots were significantly less than the cultivated check plots, the CIPC treatments and the earlier application of all chemicals caused the least reduction. Yields of corn on the untreated, uncultivated plots were very low indicating the limited ability of corn to compete with

TABLE 2.—CROP AND WEED STANDS, YIELDS, AND COVER ON CHEMICALLY TREATED PLOTS IN 1952

Treatment	CMU	CMU	CIPC	CIPC	DN	DN	Untreated Checks	
Application Rate (lbs./a.)	2	2	8	8	12	12	Cult.	Not Cult.
Application Date	5/26	6/12	5/26	6/12	5/26	6/12		
Crop stands	June 24 (plants per 25 foot of row)							
Corn	40	45	38	42	42	18*	43	...
Soybean	57*	33*	174	173	114*	0*	162	...
Crop yields	(bushel per acre)							
Corn	70	56	30*	16*	55	30*	61	6*
Soybean	10*	0*	21*	6*	16*	0*	31	14*
Weed stands	June 24 (plants per 8 square feet)							
Broad-leaved	1*	2*	30*	39*	2*	1*	...	64
Grasses	19*	59*	122*	319*	104*	2*	...	673
Weed yields	September 17 (pounds of seed per acre)							
Setaria lutescens	194	87	337	368	518	313	...	435
Ambrosia artemisiifolia	0	0	153	313	0	0	...	36
Echinochloa crusgalli	40	437	8	120	71	209	...	19
Weed cover	September 17 (percent cover by species)							
Setaria lutescens	80	7	35	40	82	50	...	57
Ambrosia artemisiifolia	0	0	62	50	0	0	...	18
Echinochloa crusgalli	17	92	1	10	12	45	...	2
Total ground cover	37	52	100	100	85	82	...	100

* Difference from check exceeding the 5% LSD.

weeds. Soybeans yielded relatively better on the untreated, uncultivated plots although yields were much lower than where weeds were controlled mechanically.

The data on crop stands and yields indicate there may be considerable latitude in the time of application of CMU, and perhaps DN, for weed control purposes in corn. There was no significant difference in the corn yields obtained on plots treated with the two pound rate of CMU at the three application dates. Such latitude is not apparent in the soybean data. CMU and DN applied at post-emergence resulted in complete failure of the crop and CIPC at a post-emergence treatment reduced yields 71% below those treated at pre-emergence.

Weed stands. All applications of CMU and DN gave good control of broad-leaved weeds while CIPC applications gave less complete control. Although all chemically treated plots had a significant reduction in the number of grassy weeds, the control on plots treated with CIPC was inadequate. The earlier CMU and later DN applications gave the best control of grassy weeds.

Weed yields and cover. Plots treated with CMU, as shown in Figure 1, B, had less ground covered by weeds than other chemically treated plots. The two most prevalent weeds were yellow foxtail and barnyard grass. There was a decrease in yellow foxtail and an increase in barnyard grass with the later dates of CMU application. Barnyard grass seed yields were very high on the plots treated post-emergence. When a large percentage of the weed cover is barnyard grass, there is danger of loss of its value to wildlife due to early lodging.

The most important weeds on plots treated with CIPC were ragweed and yellow foxtail. The plots treated with the 8-pound rate of CIPC pre-emergence were the only plots yielding less barnyard grass seed than the uncultivated check plots. Only plots treated with CIPC produced any ragweed seed. The importance of the chemical, rate, and date of application are illustrated by the ragweed data on plots treated with CIPC. The higher rates of CIPC produced more ragweed at corresponding application dates. The plots treated pre-emergence and post-emergence produced much better ragweed stand than those sprayed at emergence.

Plots treated with DN pre-emergence (shown in Figure 1, D) and at emergence had relatively pure stands of yellow foxtail and were the only treated plots whose yield of yellow foxtail seed exceeded that of the uncultivated check plots. Plots sprayed post-emergence had a mixture of yellow foxtail and barnyard grass.

Redroot pigweed (*Amaranthus retroflexus*), witch grass (*Panicum capillare*), and millet were present in the weedy growth of some plots but only in small amounts.

DISCUSSION

The value to wildlife of the weedy growth produced on the treated plots probably depends not only on the density of the stand and the total amount of seed produced, but also on the characteristics of the species composing the stand. The small seeds of witchgrass and redroot make them of limited value to upland game birds. Barnyard grass

lodged very early and this greatly reduced its value as cover. The vast amount of foxtail seed shattered completely during late September and early October and the stems then lodged. The seed was still available on the ground until covered by snow. Ragweed did not lodge and had an appreciable amount of non-shattering seed available during the late fall and winter.

The greatest amount of weed seed would be consumed during the fall. Trautman (1952) and Severin (1933) report that the consumption of weed seeds by pheasant is greatest at this time. Leopold, Lee, and Anderson (1938) and Gerstell (1938) report that pheasants, released in areas with good food and cover, show less tendency to disperse than when released in less favorable areas. Utilization of the food patch during the fall might establish the habit of feeding in this area. The planted crop of the food patch would then serve as the stable winter food when weed seed was exhausted or unavailable. Corn in particular is a favorable crop for this purpose for the grain yields are high and the ears are held above all but the heaviest snow cover.

CIPC treatments, especially the 4-pound rate, gave inadequate weed control and, although the crop stands equaled those on check plots, the yields were significantly less. The low yields on plots treated with the 4-pound rate were due principally to weed competition, while on plots treated with the 8-pound rate, lower yields are presumed to be due to injury caused by the chemical as well as to weed competition.

A consideration in the use of chemicals for weed control is the cost. Of the three materials used in 1952, the one most economically feasible at the present time is CMU. Considering the present cost of the chemical, CMU at $3.00 per pound would cost $3.00 to $6.00 per acre depending on the rate used. DN at $1.50 per pound and CIPC at $3.00 would cost from $9.00 to $24.00 per acre at the rates used. Soil preparation, planting and application of the herbicides would increase total costs.

Although it has been shown that food patches can be established without cultivation using herbicides to control weeds, many of the variables in the use of chemicals have yet to be fully explored. The response of a treated crop on different soil types varies greatly. Hybrids and inbreds of corn are known to vary significantly in their response to chemical treatments. Recommendations for the use of herbicides must be made in the light of such limitations.

SUMMARY

Six crops were sprayed pre-emergence with six chemicals in 1951 and plots of corn and soybeans were treated pre-emergence, at emergence, and post-emergence with three chemicals in 1952 to investigate the possible value of herbicides in the establishment of food patches for upland game birds.

1. Corn yields on uncultivated plots, treated with one application of CMU or DN to control weeds, equaled the yield on the cultivated untreated check plots.

2. Although weed stands may be significantly reduced by chemical treatments, the competition from surviving weeds may cause significant reduction in crop yields.

3. Initial control of weeds, the yield of weed seed, and weed cover on chemically treated plots varied with the herbi-

cide and its rate and date of application.

4. There appears to be considerable latitude in the date of applying CMU on areas planted to corn. Only the pre-emergence applications appeared of value for treating areas planted to soybeans.

5. The high corn yield over a wide range of application dates and the lower cost of the chemical would make CMU the most feasible treatment although the resulting weed seed yield and cover in the fall was less abundant than that on plots treated with CIPC or DN.

6. The relatively low cost of treatment with some herbicides, the possible elimination of care after planting and treatment, the moderately high yields of crop plants, and the supplimental weedy growth that occurs in the fall appears to make the use of herbicides a distinct possibility for establishing food patches for upland game birds.

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A PRELIMINARY REPORT ON THE USE OF FLAXEDIL[R] TO PRODUCE PARALYSIS IN THE WHITE-TAILED DEER (*Odocoileus virginianus borealis*)[1]

T. C. Hall, M.D.[2], *E. B. Taft, M.D.*[3], *W. H. Baker, M.D.*[4], *and J. C. Aub, M.D.*[5]

(From the Medical Laboratories of the Collis P. Huntington Memorial Hospital of Harvard University at the Massachusetts General Hospital, Boston, Massachusetts)

In the course of a project to study the growth of deer antlers it became obvious that work with these animals would be facilitated if they could easily and safely be anaesthetized or otherwise incapacitated. Earlier in the project when an intravenous injection was to be administered to a deer, the animal had to be driven into a chute connected with the pens in which the herd was confined. On release from the chute it was caught and wrestled to the ground and medication was administered while the animal

[R] signifies a copyrighted trade name.

[1] Reprint #795 of the Cancer Commission of Harvard University.

[2] Research Fellow of the American Cancer Society.

[3] Instructor in Pathology.

[4] Formerly, Postdoctoral Fellow, National Institute of Health.

[5] Professor of Research Medicine and Director of the Laboratories.

was prevented from struggling. This obviously is a dangerous procedure with an adult buck at any time of the year and probably should not be attempted during the rutting season. Also it entails use of a chute in which the bucks often injure their antlers during the time of growth. The drugs studied in the experiments reported here were paraldehyde, curare and Flaxedil[R] as well as neostigmine and Tensilon[R] which were used as antidotes against the latter two.

Paraldehyde was used only on deer confined to the chute. It was introduced intramuscularly, and although deer could be drugged sufficiently to allow easy handling, amounts up to 50–55 cc. were required for deer weighing from 100–150 pounds. Since this is very close to the lethal dose, one of three deer did not recover and further experiments were not made with this drug.

Curare [6] was the first drug used successfully in our experiments to relax deer for subsequent handling. This was given intramuscularly as a solution to deer in the chute, and as a paste consisting of equal parts of dry powder and glucose [7] as described in the discussion of Flaxedil[R] to deer free in the pens. The effective dose of curare was found to vary from animal to animal. The range from non-fatal relaxation appeared to be between 0.4 and 0.5 mg. per 10 pounds of body weight. (The comparable dose in humans is 2.5 mg. per 10 lbs. of weight.) The lethal dose, however, is very close to this; in one experiment 0.52 mg. per 10 lbs. body weight killed an adult buck. Neostigmine in doses from 0.03 to 0.05 mg. per 10 lbs. of body weight was given intramuscularly as an antidote for curare poisoning in some of the animals. It produced intense salivation, lacrimation, and increased bronchial secretions in the deer to which it was given. In two of five instances it caused temporary improvement in the deer's condition but failed to prevent death. Death in our opinion was due to irreversible depression of the respiratory center of the animals. In one animal death was heralded by the appearance of alternate apnea and hyperpnea which was followed by a progressively decreasing respiratory rate. In other animals only an irregular and decreasing respiratory rate preceded death. All animals developed pronounced abdominal distention. Therefore since curare exhibited an extremely narrow margin of safety with no successful antidote, it was abandoned.

Flaxedil[R] [8] (tri-(diethylaminoethoxy) benzene triethyliodide) was brought to our attention by the report of the conference on curare and related compounds. (Conf. on Ther., 1951). An aqueous solution containing 20 mg. / cc. was used for intramuscular injection. The powder was prepared in a 50 per cent paste with glucose and a portion of the paste containing a known weight of drug was applied to darts which were shot into the deer by means of a Cross-

[6] The solution of curare (d-tubocurarine hydrochloride pentahydrate) was obtained from E. R. Squibb & Co. through the courtesy of A. M. Covell. The dry curare powder (d-tubocurarine hydrochloride) was obtained through the courtesy of S. B. Penick & Co. New York.

[7] Pharmacists' glucose: obtained through the courtesy of Dr. Leslie Ohmart of the Massachusetts College of Pharmacy.

[8] Obtained through the courtesy of E. F. Voight and J. M. Ruegsegger, Lederle Laboratories Division, American Cyanamid Co., Pearl River, New York.

man rifle (Fig. 1). An excellent antidote for Flaxedil[R] exists in the form of Tensilon[R] [9] ((3-hydroxyphenyl) dimethylethyl ammonium chloride). This is inexpensive and readily available in an aqueous solution (10 mg. / cc.) which can be administered intravenously or intramuscularly. Its duration of action is reported as 8–10 minutes. (*op. cit.*)

From the data recorded in Table 1, it can be seen that the dose range of Flaxedil[R] for relaxation is approximately 2.2 to 3.0 mg. per 10 lbs. of body weight and thus the dose required is approximately six times that of curare. As can be seen from Experiment 4, 3.5 mg. per 10 lbs. was not fatal immediately when Tensilon[R] was used. It is thought that if we had been able to observe the animal further and had administered additional antidote, this animal would have survived. The death of the deer in Experiment 8 after a dose of 2.9 mg. per 10 lbs. suggests that the drug given earlier still may have been exerting an effect. Why a dose of 4.0 mg. per 10 lbs. of body weight had only a minimal effect (Expt. 11) is difficult to explain. It may be that some was lost from the syringe when the injections were given. It is more probable, as in Experiments 5 and 6, that a cumulative effect of this dose was not obtained in the hour interval, for Flaxedil[R] usually exerts its maximum paralytic effect in 20–40 minutes. (*op. cit.*)

From these preliminary observations we conclude that Flaxedil[R] may well prove to be the drug of choice to produce muscular relaxation in deer. It must be emphasized that the dose of this drug is not yet standardized and our present procedure is not without risk. This procedure is as follows:

1. Darts as shown in Figure 1 are prepared by applying a known weight of a paste composed of equal parts by weight of Flaxedil[R] powder and pharmacists' glucose. The paste hardens after application and becomes firmly attached. Excess stored in a closed container will become malleable and ad-

[9] Obtained through the courtesy of E. L. Sevringhaus, Hoffman-LaRoche, Inc., Nutley 10, N. J.

FIG. 1. EQUIPMENT USED FOR PARALYZING DEER WITH FLAXEDIL[R] AND CURARE

The rifle is a 22 Gauge Crossman, powered by compressed carbon dioxide contained in the cylinder below the gun. Darts are distributed by S. E. Laszlo, 25 Lafayette Street, Brooklyn, N. Y. The dart shown has been lengthened by forcing a piece of pointed and circularly grooved aluminum wire over the original tip. The grooves are filled with Flaxedil-glucose paste, as shown in the insert.

TABLE 1.—EFFECT OF FLAXEDIL[R]

Expt. No.	Animal* No.	Age yrs.	Wgt. lbs.	Intramusc. Flaxedil[R] mg./10 lbs. body wt.	Form of Administration	Intramusc. Tensilon[R] mg./10 lbs. body wt.	Effect
1.	265	½	55	2.0	solution	...	No apparent effect
2.	265	½	55	4.0	solution	...	Death in 5 min. (Dose given same day 2 hrs. after Expt. 1)
3.	267	½	41	3.0	solution	2.5 in each of 4 doses	Paralysis in 10–15 min. Recovery after 1 hour with Tensilon[R] treatments.
4.	274	½	45	3.5	solution	2.5 in each of 6 doses	Paralysis in 5 min. Apparent recovery after 1 hour but found dead the next morning
5.	264	½	55	1.5	dart	...	No apparent effect
6.	264	½	55	1.1	dart	...	No apparent effect (Dose given 30 min. after that in Expt. 5)
7.	264	½	55	...	....	54.5	Marked salivation & lacrimation but otherwise not affected. (Dose given 1 hr. after Expt. 6)
8.	264	½	55	2.9	dart	...	Death in 3 min. (Dose given 2 hrs. after that in Expt. 5)
9.	263	½	60	2.5	dart	16.7	Paralysis in 10–15 min. Recovery after Tensilon[R] therapy
10.	275	½	64	2.2	dart	?	Collapsed & could not walk, but not complete paralysis in 10–15 min. Recovery after Tensilon[R] therapy
11.	300	adult	133	4.0	solution, in divided doses over 1 hour	...	Minimal loss of muscular control

* All of these deer were females.

hesive if warmed slightly. No attempt has been made to sterilize the darts nor to use aseptic technique for intramuscular injections. There have been no complications from sepsis.

2. Weight of the deer is estimated. In our experience such estimates may be incorrect by as much as one-third. However, the wide margin of safety and the availability of an adequate antidote make somewhat inaccurate estimates of body weight relatively unimportant.

3. A dart or darts are introduced into the animal, preferably in the shoulder or thigh, to approximate 2.5 mg. Flaxedil[R] per 10 lbs. of body weight.

4. Respiratory paralysis, should it ensue after the development of muscular relaxation, can be controlled with intramuscular or intravenous doses of Tensilon[R], 2.5 mg. per 10 lbs. body weight, at intervals of 10–15 minutes for 1–2 hours until the normal muscular activity of the deer is maintained. Tensilon[R] is apparently a very safe drug as can be seen from Experiment 7 in which

54.4 mg. per 10 lbs. body weight were given to an animal with only minimal production of lacrimation and salivation.

5. In the event of a large overdose of Flaxedil[R], artificial respiration can be administered by means of a simple and easily portable apparatus consisting of an endotracheal catheter, an insufflation bag and a small oxygen tank. This is preferable to mechanical artificial respiration which causes regurgitation of enteric contents and distention of the rumen with air. Inasmuch as this drug in our hands produced none of the central nervous system depressing effects of curare, artificial respiration might be expected to be profitable in deer with severe Flaxedil[R] paralysis.

SUMMARY

Some experiments are described using paraldehyde, curare and Flaxedil[R] as paralytic agents in the white-tailed deer. Paraldehyde was used only briefly because it required that the animal be restrained in a chute while it was being administered and because there was a narrow range between the stupefying and lethal doses. Furthermore, complete paralysis was not attained. Curare was a potent paralyzing agent, but the narrow margin of safety rendered it dangerous to use. Neostigmine was of doubtful value as a curare antagonist. Flaxedil[R] is apparently the agent of choice because of its wide margin of safety, its freedom from undesirable side effects and the availability of an effective antagonist, Tensilon[R]. Flaxedil[R] is a synthetic compound and therefore inexpensive, easily available and of uniform strength.

ACKNOWLEDGMENTS

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AERIAL METHODS OF ASSESSING RED SALMON POPULATIONS IN WESTERN ALASKA

George J. Eicher, Jr.

U.S. Fish and Wildlife Service, 2725 Montlake Boulevard, Seattle 2, Washington

Visual Surveys

In western Alaska, principally in the Bristol Bay region, aerial methods of recording quantitatively sizes of populations of red salmon (*Oncorhynchus nerka*) on spawning grounds have been highly developed. The streams are generally shallow with little overhanging foliage, and in spawning colors the fish are bright red and highly visible. These characteristics increase the efficiency of aerial surveys.

The first recorded aerial stream survey in Alaska was made by C. M. Hatton, a special employee of the U. S. Bureau of Fisheries, in the Lake Clark district of Bristol Bay in 1930. Since his late arrival in the area precluded his making a ground survey he chartered an airplane to make a visual survey of the spawning beds.

In 1931, Dennis Winn, Bristol Bay Management Agent of the Bureau of Fisheries, undertook the first extensive aerial spawning ground surveys which lacked significant success because the airplane used was available for only a brief period during which low ceilings prohibited flying at an altitude sufficient to permit good observation.

Serious use of aircraft for surveys was not continued until 1937, when Agent Fred O. Lucas used this method because of lack of funds and personnel for ground surveys. In 1938 George B. Kelez, initiating a biological research program in Bristol Bay for the Bureau of Fisheries, joined with Lucas in aerial surveys, and in ensuing years developed the methods now employed.

In the widespread spawning grounds, the only alternative to aerial surveys is coverage by parties operating from boats. Because of the distances involved and the relatively short spawning season, it would be impossible for any party to cover more than one system or part of a system. To cover all of the grounds in the Bristol Bay area, nine parties of two men each would be required, complete with boats, outboard motors, camping equipment, and supplies to last a month. And even with this large crew, several major sub-systems could not be covered because they are inaccessible by boat.

Experience has shown that ground parties cannot develop accuracy of assessment comparable to that of the observer in the airplane. On small streams the former method approaches complete accuracy. However on broad streams, on lake beaches, and on large schools in the mouths of streams, surface methods of observation cannot give more than vague impressions of numbers because of reflections, the tendency of the salmon to flee when approached, and the inability of a man to see far below the surface from the angle of view obtained.

One pilot and observer team covers all of the grounds not once but three times during the season to assure observations during the peak of spawning.

Season costs of the aerial survey are under $1,000 compared to a ground-party cost of over $10,000 for manpower alone.

In developing the methods now used, Kelez (1947) made use of ground parties counting spawners on streams on the days of aerial observations. The men on the ground, in addition to making one-by-one counts of the salmon, established stations at one-mile intervals with markers visible from the air. In this way comparison of counts was readily achieved and compensations worked out.

Guessing of numbers is not suffiiciently accurate. In the aerial method developed by Kelez, two experienced observers viewing the same grounds do not differ significantly in their estimates. Ideally, observers should have a background of experience in one-by-one ground counts of spawning fish in each area so they readily appreciate varying conditions of distribution in spawning array, ranks, or schools in terms of numbers as peculiar to each bottom or water type. The inexperienced observer invariably tends to overestimate numbers of fish.

The training of observers involves working with groups of known numbers of fish in training flights during which the trainee and pilot develop teamwork. The pilot undergoes indoctrination in approaching the fish in the correct manner, keeping the observer in visual contact with the fish, maintaining proper altitude, and keeping the airplane in correct relationship between sun angle and fish to avoid glare. Study and counting of fish in aerial still photographs, as well as scrutiny of color motion pictures of red salmon in various spawning distributions taken from the air, aid in developing accuracy in the new observer.

The survey airplane moves over the stream or beach at a constant altitude. The observer varies his procedure with the concentrations of fish. On sparsely covered grounds the fish are individually counted with a hand tally. On the majority of normal groups the observer counts ten individuals, mentally connects ten such groups into a block of 100 fish, and then divides an entire group into such blocks. When large groups are present, it is necessary to circle continuously until all fish are counted. On broad streams with heavy spawning, blocks of 1,000 fish are similarly developed. As may be expected, accuracy is inversely proportional to density of populations.

Choice of altitude is extremely important. The usual impulse of beginners is to fly too low, with the result that they cannot possibly encompass what they see quickly enough to make mental records. The correct altitude depends normally on the speed of the aircraft, with certain limitations. Altitudes of less than 500 feet do not permit the observer to see a broad enough area to accurately cover the fish. Above 900 feet difficulty is experienced in seeing some fish. The speed-altitude table below might be of general application:

Speeds in Miles Per Hour	*Altitude in Feet*
Up to 70	500
70 to 90	600
90 to 110	700
110 to 130	800
130 to 150	900

It is fruitless to attempt accuracy at speeds above 150 miles per hour. A

speed of approximately 75 miles per hour at an altitude of 600 feet provides the best results. Efficiency diminishes rapidly at speeds in excess of 100 miles per hour although general qualitative impressions without reference to actual numbers can be gained at higher speeds and greater altitudes.

Conditions of light and sun angle are important. Good surveys cannot be made late in the day when the sun angle is poor and continual change is made from deep shade to sunshine. Glare is a factor that may be reduced with polaroid glasses.

Fatigue is extremely important. Both pilot and observer suffer reduced efficiency after periods of uninterrupted survey. It has been found that by breaking up the period by landing and relaxing it is possible to extend the survey to six hours, not including the return to base. However, it is inadvisable to attempt more in one day.

Choice of aircraft becomes a compromise between desirability and availability. It is difficult to obtain all the desirable survey qualities in one aircraft and still retain its usefulness for other projects. A craft of versatile use with retention of good survey features would be a four-place high-wing monoplane with good visibility downward on either side. It should be capable of safe maneuverability at speeds under 90 miles per hour and should have a good rate of climb to combat downdrafts, a low fuel consumption, and a normal range of at least five hours.

Safe maneuverability dictates carrying the lightest load possible. Survey trips are not occasions for anyone to "go along for the ride."

PHOTOGRAPHIC SURVEYS

Kelez (*loc. cit.*) dwelt on the possibilities of vertical aerial photography as a means of providing permanent records of spawning numbers in various locations. Under a project jointly developed with Kelez, the writer initiated experimental work in this procedure during the 1947 season. An F-56 Fairchild aerial camera with $8\frac{1}{4}$-inch lens was mounted in the after belly of a Norduyn Norseman aircraft on floats. The F-56 is a military-type camera, electrically wound and operated, although it can also be operated manually. Stops from f=4 to f=22 are provided and a between-lens shutter gives speeds of 1/75, 1/125 and 1/225 second. Approximately seven-inch-square pictures are made on roll film in lengths up to 125 feet.

Development of the photographic system involved two main categories of problems. First was finding film, developer, and filters that would provide the highest contrast between fish and background and make the best use of light rays transmitted by water. Secondly it was necessary to find means of obtaining pictures against the odds of low light intensity, high shutter speeds and relatively small diaphragm stops.

The craft used for photographic surveys has been the result of availability rather than choice. The Norseman was used one season, following which the camera was mounted in a twin-engined Beechcraft 18-S. It has been used in that airplane to this time. Both of these aircraft are too fast and lack maneuverability and effective communication between pilot and photographer. The most serious disadvantage is the lack of visibility ahead and down. This last

feature means that many retakes are necessary because the first runs are to one side of the intended picture area. This centering difficulty necessitates higher-than-desirable altitudes.

High speeds predicate high shutter speeds, which in turn mean larger diaphragm openings and intensify the problem of obtaining enough light to give good pictures. This is particularly critical in view of the high light demand of the filters normally employed. Diaphragm openings greater than f 5 result in poor coverage to the corners of the picture.

Camera movement in relation to the ground is a continuing problem with higher speeds. At 1/225 second exposure, the fastest shutter speed available, the camera moves over the ground 5.4 inches at 70 miles per hour, 7.7 inches at 100, and 9.2 inches at 120 miles per hour during the period in which the shutter is open. With fish averaging 25 inches in length, blurring is difficult to eliminate.

The ideal photographic aircraft includes features similar to those previously cited for a visual survey airplane.

The high light demand occasioned by the peculiarities of underwater photography is alleviated by using film with an index speed of 200 increased to 1,000 through use of a special developer. Orthochromatic film would provide the utmost contrast between the red fish and the bottom; however this is not available in aerographic roll film. Infrared film is often suggested as theoretically it could produce white-appearing fish in dark water. In practice, however, it produces jet-black water with nothing visible below the surface. In printing, maximum contrast is obtained by using the hardest paper available and strong developing solutions.

Filtering is one of the principal research grounds in this problem and one in which efforts continue. The most successful filters used include a deep yellow, a dark green Wratten No. 57, and a light green Wratten No. 59 A. No single filter is usable in all situations, the selection depending mainly upon the type of bottom and water depth. Best results were obtained on most gravel and sand bottoms using a yellow filter with a factor of 2.0. On bottoms covered with vegetation or algae, the Wratten 59 A with a factor of 3.5 was most effective. In deeper water the Wratten 57 (factor of 5.0) was most receptive to the spectral rays transmitted by water. A pola-screen with a factor of 2.0 was of value in reducing reflections.

The normal altitude employed with aircraft used to date was 1,000 feet. Use of a slower airplane with good visibility would permit altitudes as low as 500 feet and would cover a ground strip about 510 feet in width. With a slow, easily directed airplane, the minimum altitude would be governed only by the width of the spawning ground and the latitude of stream meander.

Obviously to photograph all, or even a large part, of the spawning grounds would necessitate prohibitive quantities of film, time and facilities to process and interpret pictures. Instead, representative areas are chosen to provide indices to adjacent spawning grounds. Normally the mouths of streams are covered, as well as portions of easily identifiable spawning grounds above. Beach spawning areas and broad, short spawning grounds such as frequently occur at outlets of lakes or in streams connecting

lakes are often covered in their entirety. In this way every major spawning ground is represented. By using a large number of index areas, an average is reached which tends to compensate for the expected sampling variations. Approximately one thousand photographs are made on the Bristol Bay spawning grounds each year.

Timing of photographic trips is highly important if pictures are to be valid indices, but fortunately peculiarities of the area and the fish favor representative coverage. For example, the grounds must be covered in close proximity to the peak of spawning, and although peak periods vary among systems, variation has been well established through years of visual surveys. The salmon arrive on various spawning grounds from one to seven weeks before spawning. Salmon are present on the grounds for another two weeks between the time when spawning commences and death of the fish. Thus a minimum period of about three weeks is available within which coverage can be assumed to be representative of the run. Photography is scheduled for the mid-point of this three-week interval.

Visual advance coverage reveals the progress of spawning. The pictures themselves show the status of spawning. Earliness is indicated by large schools of fish with few nests. Widespread spawning, few schools, and few or no spawned or dead fish indicate ideal peak timing. Absence of schools, empty nests, and large numbers of dead and partially-white spawned fish indicate late coverage.

In interpreting the pictures, a sheet of clear plastic gridded into one-tenth-

FIG. 1. A section of spawning grounds of Kejik River in the Lake Clark region of Bristol Bay. Note complete absence of salmon. Photograph made August 14, 1949.

inch squares is laid over the photograph and the fish are counted. When numbers are small, one-by-one counts are made. On large spread-out grounds, counts of representative squares are made and the average multiplied by the total squares covering fish. In the case of particularly dense schools, estimates of the average numbers in each square are made along with the actual water surface area covered by each square and the number of fish determined by visible shadings of density. Lines are drawn on the photographs connecting prominent objects serving as reference points, and the fish bounded by these lines are those counted each year.

The prints are filed by area; negatives are retained and handled in the original rolls. The 65-foot size is most easily handled. Film processing is accomplished with an automatic continuous-roll-film kit, a simple and compact apparatus utilizing three five-quart containers for solutions. Drying is done with a portable rapid film dryer developed for the military. In processing, film is wound and rewound through the solutions from one reel to another. To avoid inadequate development near the roll ends, the last five frames are left unexposed and the five-foot leader on the other end retained when processing.

Aerial photographs provide a permanent index, free of the vagaries of human memory and error, for rating visual counts. Adequate coverage is provided in large beach and stream areas or in heavy concentrations, permitting accuracy of assessment not approached by any other method.

Figures 1 and 2, taken August 14, 1949

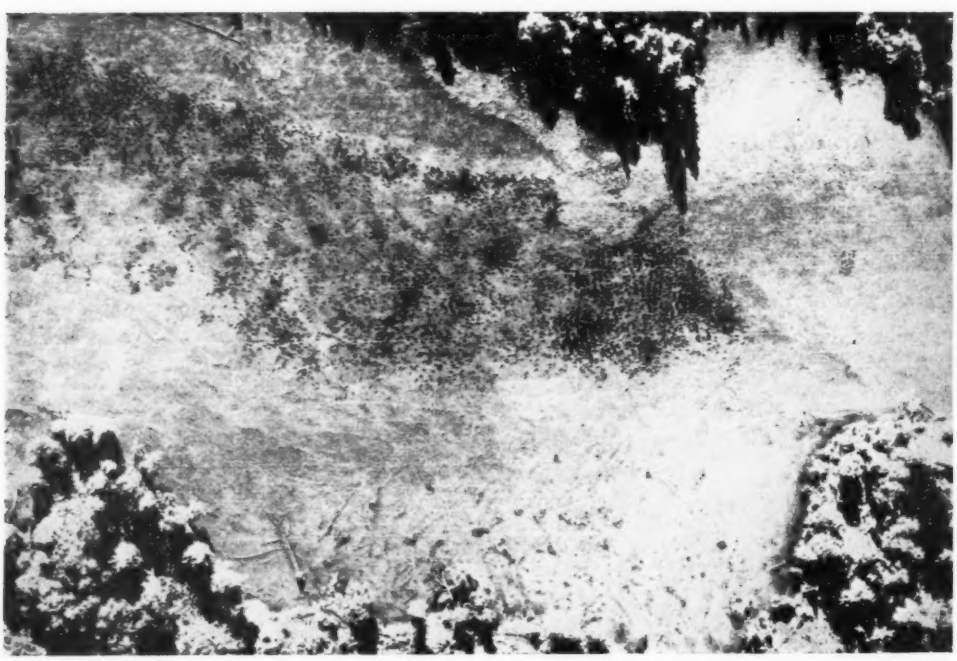

FIG. 2. Identical section of the spawning grounds of Kejik River appearing in Fig. No. 1. Only red salmon utilize these spawning grounds at this time. Photograph made August 21, 1952.

and August 21, 1952, show an identical portion of the Kejik River spawning grounds in two different years. Visual surveys found the spawning escapement to the Kejik notably poor in 1949 and very good in 1952. The seven-day difference in the dates of coverage is not considered sufficient to affect the counts. In 1952 a visual survey on August 16 found the same numbers of fish present, and in 1949 similar coverage two weeks after the photographic survey also found no fish present at this spot. This particular area is one impossible of accurate coverage by ground parties as the stream is quite broad and the fish, when present, quite concentrated. Visual aerial coverage yields good results in an area of this type but falls short of the accuracy to be obtained from pictorial records.

The photographic method of survey is relatively inexpensive. At present, cost of the aircraft charter is about $600, film $150, developer $50, and processing $200—a total of $1,000. With a small airplane used simultaneously for visual surveys, this figure would be approximately halved. This is an insignificant cost for a permanent record of spawning populations on which hinge an industry with an annual production in excess of twenty-five million dollars.

SUMMARY

1. A method of visual aerial survey of spawning red salmon on Bristol Bay grounds has been developed for assessing the populations quantitatively.

a. Best results are obtained with good light conditions using an airplane speed of 75 miles per hour from an altitude of 600 feet. The best aircraft for the purpose is a four-place, long-range, high-performance craft which can be safely and easily maneuvered at speeds under 90 miles per hour.

b. Fatigue lowers efficiency of survey and no more than six hours should be attempted in one day.

2. The use of vertical aerial photographs provides permanent records of indices to spawning numbers, removes much of the human error from visual counts and provides greatest accuracy when large schools are encountered.

a. Aircraft qualities for photography parallel those needed for visual surveys but in addition include good visibility ahead and down, and low, safe, minimum speeds.

b. Using an F 56 camera with $8\frac{1}{4}$-inch lens, altitudes range from 500 to 1,000 feet depending upon stream width and adaptability of the aircraft.

c. Yellow, green, and polaroid filters are used in conjunction with fast panchromatic film to give greatest contrast between fish and bottom. The greatest problems arise from high light demand and camera movement.

d. Problems in coverage at the correct time to include all spawners are alleviated by concurrent visual surveys and consistency of the species.

e. Photographs are interpreted by counting fish in squares on a plastic grid superimposed on the print. Area of each square of the grid can be computed from the known altitude.

3. Visual and photographic methods of aerial coverage are less costly than ground counts and provide higher degrees of accuracy.

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REVIEWS

An Angler's Entomology. By J. R. Harris. Collins, London. xv + 268 pp. + 48 plates. 1952. 25 s. (about $3.50).

It was with pleasure that I undertook reviewing this book. "An Angler's Entomology" is a beautiful volume, as are all others in the New Naturalist Library. There are 103 color photographs of living or recently killed aquatic insects and of artificial flies. In addition there are 16 black and white plates, mostly of typical habitats where the various insects are found. J. R. Harris is limnologist at Trinity College, Dublin, and apparently an avid angler. British trout fishermen take their fishing more seriously and study all aspects of stream life more than do most American anglers. The book deals with aquatic insects of the British Isles in a fashion to satisfy both biologist and sport fisherman.

Most emphasis is upon mayflies (Ephemeroptera) although stoneflies (Plecoptera), caddis flies (Trichoptera), midges and gnats (Diptera) and a few other aquatic insects receive some attention. The descriptions, keys, and photographs are such that even a novice should be able to identify most species. Emphasis is upon field identification. Methods of flight or other behavior characteristics are described to aid in identification, and also in wise use of artificial flies. *E.g.* (p. 164) "When the freshly emerged spinner" [of *Caenis* spp.] "flies away, the empty skin of the dun is left adhering to the support chosen, and sometimes one's clothing will be covered with these tiny white exuviae. The flies may be recognized from this habit alone." "When fishing for trout which are concentrating on *Caenis* it is necessary to cast accurately so that the fly floats directly over, or slightly in front of, the fish. At other times fish may move several feet across stream and accept a badly directed fly, but they seldom do this when *Caenis* is on the water."

Harris applies common names to all species important to fishermen and correlates these with previously used names for flies and for artificial flies. Instructions for dressing many of the commoner dry and wet flies are given.

Life history notes and notes on ecology of the various insects indicate a first hand familiarity and several years of careful observation.

Although only insects from the British Isles are included, *An Angler's Entomology* should be of much interest to American biologists and anglers. It is suggested as a fine gift for your angler friends.—K. D. CARLANDER.

How to grow minnows. By Philip F. Allan. Privately published. 1801 Carleton Avenue, Fort Worth 7, Texas. 63 pp. 1952. $1.00.

Production of bait minnows in the southeast. By E. E. Prather, J. R. Fielding, M. C. Johnson, and H. S. Swingle. Ala. Poly. Inst. Agr. Exp. Sta. Circ. **112**: 1–71 pp. 1953. $.52.

The rearing of minnows has become a popular endeavor in recent years—particularly in the southern states where growing seasons are longer and the dangers of winterkill in small ponds are at a minimum. As in most new enterprises, many people have tried minnow rearing with little success; others have been quite successful. These two booklets present in simplified form many of the rules and methods which should be followed if the more common failures are to be avoided.

The subject matter covered by the booklets is quite similar. Each has sections on selection of site, construction of ponds, rearing of various species of minnows, transportation and handling, and control of pests and predators.

"Production of bait minnows in the Southeast" deals with problems of minnow rearing in southeastern states, with emphasis on goldfish. Fathead minnows and golden shiners are discussed in less detail. The latter species are more difficult to handle in warm water than goldfish. "How to grow minnows" is not specifically limited to any area and gives suggestions presumably applicable throughout the United States. In many areas of the country, however, too little work has been done to know if the suggestions will apply equally well in all regions. Allan includes data on the common sucker and bluntnosed minnow as well as on the three species discussed in the other pamphlet, but the raising of none of the species is as thoroughly explained as is that of the goldfish in the Alabama publication.

Plans and specifications for the construction of ponds are given in greater detail in "How

to grow minnows"; the desirable features of ponds are more clearly explained in "Production of bait minnows."

Both publications are well illustrated: 24 photographs, drawings and layout plans in Allan's book; 33 figures, mostly well-selected photographs, in the Alabama book. Both books are quite readable. I found Allan's style a little abrupt and overly condensed.

For the person who knows little of the rearing of fish and who wants to determine whether he should take a chance on commercial minnow production, I would recommend Allan's book first, since it tells more of costs and equipment. Anyone who is actually going into business will want to be familiar with both books. Fisheries biologists will find more new material in "Production of bait minnows in the southeast." It summarizes much first hand experience in experimental raising of goldfish and other species.—K. D. CARLANDER.

Fresh-water Invertebrates of the United States. By Robert W. Pennak. 1953. The Ronald Press, New York, ix+769 pp. $14.00.

Dr. Robert W. Pennak has filled a long-recognized need in providing a modern comprehensive summary of the fresh-water invertebrates of the United States. The almost impossible task has been accomplished in a scholarly fashion — systematically arranged with a selection of those details most significant to fresh-water biologists. There are over 2300 drawings of animals, or of details of morphology which will aid in identification. The drawings, type, and general layout are unusually clear, making an attractive as well as useful book.

Comparisons will naturally be made between this book and "Fresh-water Biology" by Ward and Whipple which has been the standard reference since 1918. In the first place the new book is limited to the free-living invertebrates and does not include the bacteria, algae, higher vegetation, parasitic worms and vertebrates which were included in the older text. Other modern texts have already made those sections of Ward and Whipple largely obsolete. Secondly, Dr. Pennak has achieved a greater uniformity and readability than was possible in Ward and Whipple where each chapter was written by a different specialist. Each of Pennak's chapters was submitted to one or more specialists to ensure accuracy.

Each of the chapters on various groups of animals has an introductory section followed by keys and a selected list of references. Each introductory section gives general characteristics of a group, its anatomy, with particular reference to features used in classification, physiology, reproduction, ecology, and methods of collecting, culturing, and preserving specimens. Additional topics of interest and importance are inserted in logical sequence, as for example, cyclomorphosis or seasonal changes in morphology (of rotifers and cladocera), parasitic copepods, and freshwater jellyfish.

The keys are to species in the small, fairly stable groups where it is probable that comparatively few new species will be added in the next few years: Porifera, Coelenterata, Turbellaria, Bryozoa, Hirudinea, Eubranchiopoda, Clodocera, Copepoda, and Amphipoda. In a few groups where only one or two species are known, there are no keys but descriptions of the species: Nemertea, Polychaeta, Mysidacea, and Neuroptera. In the Isopoda and Collembola the keys are to the "common" species, since these groups are but poorly known. The keys to species indicate the geographical ranges of each in United States. In larger taxonomic groups, in groups less well known in the United States, and in groups where the taxonomy is in need of much revision, keys are to genera: Protozoa, Gastotricha, Rotatoria, Nematoda, Nematomorpha, Tardigrada, Oligochaeta, Ostracoda, Decapoda, Hydrocarina, Plecoptera, Ephemeroptera, Odonata Hemiptera, Megaloptera, Trichoptera, Lepidoptera, Coleoptera, Diptera, Gastropoda, and Pelecypoda. The key to Protozoa includes 303 of the about 450 genera of free-living Protozoa reported from freshwaters of United States. These genera were selected as most significant by 8 well-known Protozoologists. For the Gastrotricha and Tardigrada the keys are to the genera known from the world since their distribution in U. S. is poorly known. The keys to insects are to aquatic forms, nymphs or larvae of most groups. Keys to adults are given only for Hemiptera and

Coleoptera. All keys are of the couplet type. In the little experience the reviewer has had with the keys, he found them clear, workable, and well illustrated.

The first chapter, or Introduction, deals with a number of topics of general interest: origins of fresh-water fauna, fresh-water emigrants to the sea, major distinctions between marine and fresh-water invertebrates, atypical fresh-water habitats, dispersal and barriers, and food webs. A very interesting graph of the numbers of marine, fresh-water and brackish species found at different salt concentrations indicates that the smallest number of species is found at about 7 parts per thousand. In another table, various orders, classes, and phyla of invertebrates are listed according to their occurrence in marine, fresh-water and terrestrial habitats.

A number of other tables or diagrams summarize in readily grasped fashion several interesting aspects of invertebrate aquatic biology: *e.g.* sequence of generations in a typical ploimate rotifer, orders of crustacea found in fresh and/or marine waters, morphological features of orders of fresh-water Crustacea, arrangement and terminology of appendages of fresh-water Crustacea by orders, chief features of larval net and case construction in families of Trichoptera.

Two appendices, one on field and laboratory apparatus and the other on reagents and solutions should prove of great value to anyone wishing to collect and study fresh-water invertebrates. The index includes all names of genera, subgenera, species and subspecies, as well as other systematic groups used in the book and the principal citation page is indicated in boldfaced type for quick reference.

The author states (p.vi): "In a sense, this book constitutes a plea and encouragement for more work on our rich but poorly known fresh-water invertebrate fauna." This plea is given real substance in the manner in which each chapter summarizes the present status of our knowledge, outlines the methods of collection and study, and lists the important literature.

Every aquatic or waterfowl biologist dealing with fresh-water fauna will find Pennak's contribution extremely valuable. Any biologist will find much of interest in it.—K. D. CARLANDER.

Birds and Mammals of the Sierra Nevada. With Records from Sequoia and Kings Canyon National Parks. Lowell Sumner and Joseph S. Dixon. University of California Press, Berkeley and Los Angeles. xvii + 484 pp. 1953. $7.50.

As a rule the wildlife manager is concerned chiefly about the welfare of game species. Because his job is to provide an annual crop for sportsmen to harvest, he rates other animals according to their effect on that crop. If beneficial they are encouraged, if neutral they are ignored, and if harmful they are suppressed. Under these circumstances in which the success of the manager is judged by the size of the hunter's bag, little thought is given to the intangible values of wildlife. Whereas every effort is made to encourage economically valuable animals such as deer, predators like the coyote may be ignored or looked upon with disfavor. But to the lover of the out-of-doors, as all sportsmen should be, the coyote with its "wonderful, wild voice," "as much a part of the West as the smell of sagebrush and the limitless unfenced vistas," is even more worthy of preservation for its own sake than is an over-managed herd of deer. Symbolic of the wilderness, rich in wild beauty and mystery, the song of the coyote heard at night beyond the dimming embers of a campfire is never to be forgotten. Its value to the listener is not expressible in terms of dollars and cents; but, as the authors of "Birds and Mammals in the Sierra Nevada" ask, does that make it any less precious?

This book, besides offering an abundance of information on many of the animals of the Sierra Nevada, presents the point of view of naturalists associated with the United States National Park Service. The philosophy of these men, who have dedicated themselves to preserve for posterity the intangible values of wildlife, is expressed in short chapters on "Wildlife policies and problems" and "Human use of parks" and in many of the species accounts of birds and mammals. A chapter entitled "Life-zones" is included for the benefit of park visitors who are impressed by the changes in vegetation to be seen when one goes from the dry, hot floor of the Great Valley to the peaks that rise higher than timber line. A more effective presentation of

this latter subject would have brought the photographs depicting life-zones and the life-zone map into the chapter and would have included a table summarizing the characteristics of each zone. The illustrations in the book include two maps to show the principal features and life-zones of Sequoia and Kings Canyon National Parks, eight color plates from Hoffmann: *Birds of the Pacific States* and Grinnell, Dixon, and Linsdale: *Furbearing Mammals of California*, and forty-six photographs by the authors. A forceful argument against uncontrolled utilization by stockmen of the rangeland of our National Forests is to be found in photographs illustrating destruction of mountain meadows by domestic stock.

The species accounts comprise the bulk of the book. The studies on which they are based began in 1916 when the Museum of Vertebrate Zoology of the University of California organized a field party to investigate Kings Canyon in the southern Sierra Nevada Mountains of California. Subsequently, when the area became a National Park, the Park Service had Sumner undertake ecological studies which would parallel those Dixon was then making in the adjoining Sequoia National Park. In 1947, after Dixon had retired from the National Park Section of the United States Fish and Wildlife Service, Sumner was assigned the task of revising the Sequoia-Kings data "in such manner as to make them more useful to the average park visitor." In so doing he drew upon the unpublished records of Superintendents, Naturalists, and Wildlife Rangers of the two parks. The result is the present volume. Unfortunately, a misleading title was chosen. From it a reader would expect all of the Sierra Nevada to be covered. Instead, the text emphasizes only the Sequoia-Kings region, and Sierran species not occurring in that segment are excluded.

To the wildlife technician, the book is of interest for its discussion of problems that arise in implementing the National Park Service policies, "which are based on the obligation to preserve natural conditions," and for its many accounts of predator-prey relationships. Although the problems of Park Naturalists are somewhat different from those of wildlife managers on the outside, they are no less difficult. Imagine the complications in trying to preserve the natural features and wildlife of an area while developing it for the convenience of large crowds! Among the topics discussed are noninterference with wildlife, restoration measures for upset environments, confinement and feeding of animals, and boundary deficiencies.

The species accounts provide a wealth of natural history data. Each is well organized and clearly written. There is a description of the animal, a general discussion of its habits, and a listing of park status and records. The excellence of many of the observations is exemplified by Walter Fry's fascinating story of the nesting of a pair of pileated woodpeckers—successful even though the female was killed by a Cooper hawk shortly after the young had hatched —, and of the wolverines who "came bristling up" to rob bears, coyotes, and mountain lions of their food. Regretfully, there are no citations in the text to the photographs, all of which are lumped together presumably for economy's sake. For example, the discovery of a coyote den is discussed on page 347, but the unusual photograph (Figure 18) of the pups peering out of that den is not noted. Likewise, captions for pictures do not refer to text. Figure 27 is a rather poor photograph of a doe standing on her hind legs to eat buckeye. I wondered why it was included. Later, when reading the deer account, I learned that the doe was pregnant and that she sought the calcium-rich foliage of buckeye because she needed calcium for her fetus.

One of the wildlife problems confronting National Park administrators is the matter of artificial feeding. As with game animals on the outside, there is constant demand from the public that food be supplied to help certain species over unfavorable periods. The wildlife technician who needs an additional argument to combat these demands could cite the experience of Steller jays in the park. Many young birds which all summer had eaten only campers' scraps died at the end of the season when their benefactors went away. During time of artificial plenty they had not learned how to forage for natural food. The book also mentions the situation at Glacier National Park where "one band of bighorn was almost exterminated by a lung disease before biologists

discovered that the only way to save the remnant of the herd was to stop the artificial feeding." For the public there is a good explanation of why the Park Service discontinued the garbage shows which on a big day would attract several hundred people as spectators and forty or fifty bears as participants.

Another headache for the park administration is the task of explaining the beneficial effect of predators on prey species. Some park visitors seeing a small but audacious weasel capture and devour fat chipmunks at public campgrounds become very angry and demand that the management shoot weasels. But park policy states that "No native predator shall be destroyed to protect another park animal on which it normally preys, unless that animal is in immediate danger of extermination, and then the predator shall be killed only if it is not also a vanishing form." For persons who cannot understand or appreciate this policy the book gives many arguments in defense of predators. "In wilderness areas the mountain lion acts as a natural ally of the forest by preventing an overpopulation of deer that, if unchecked, ultimately would destroy nearly all young trees and seedlings." Close observation has shown that the California jay kills mainly inferior young quail which are "thus prevented from transmitting their defects to another generation." Old records indicate that "often where bobcats were thickest quail were most abundant." And the dipper, by catching the slowest and least alert fish or those with disease "helps to maintain the vitality and vigor that distinguish wild trout from tame, hatchery-raised fish." The authors believe that sportsmen who persecute roadrunners because they occasionally catch young quail could benefit "the quail infinitely more by expending an equal amount of energy on restoring their depleted food and shelter." And criticism of "the butcherbird by meat-eating man, who, without personal danger, daily kills and eats more vertebrates than any other creature in the world, betrays a self-righteousness of which the simple butcherbird at least is not guilty." Another animal about which people complain is the porcupine. Some persons contend that because this ungainly rodent looks ugly while trees are beautiful, the Park Service should destroy "porkys" on sight; and even professional foresters have been concerned about the possible effect of porcupines on park trees. The authors answer that forests have survived in spite of the porcupine, and, anyway, most visitors get a greater thrill from meeting a fearless "porky" than from seeing one more of countless thousands of pines.

At times the authors are over-zealous in trying to demonstrate the importance of a species to the biotic community. The statement, based on an essay by Grinnell, that a mountain "forest in reproducing itself with the help of gravity alone would eventually slide from the mountains into the unfavorable lowland environment and there die out," stretches a point. The assumption is that since "cones and seeds naturally roll downhill," forests are perpetuated by jays and other seed-storing creatures planting uphill. But the fact of the matter is that forests seed themselves uphill even without the aid of animals.

Such over-zealousness, though, is a small matter. It is a by-product of the spirit in which the book was written—an eagerness to give the reader an understanding of the complexity of the interdependencies of wild animals compared with kinds that depend wholly or partly on man for their support. The authors also wanted the reader to feel their own keen appreciation of the intangible values to be derived from seeing or hearing wildlife free and unregimented in its native state, and their conviction that "the unspoiled grandeur of the parks symbolizes America as no logged-over area, reservoir, crowded city, or beanfield ever can symbolize it."

For me the book was particularly encouraging because from it I realized that so long as wildlife policies of our National Parks are established and implemented by men who think and feel as do the authors of "Birds and Mammals in the Sierra Nevada," we can rest assured that in the parks at least the beauty of our wilderness will be preserved. Elsewhere in the name of progress we are gradually destroying many of the intangible values of wildlife. Already over most of the West sodium fluoroacetate has silenced the song of the coyote; but thanks to the far-sightedness of a few men, the parks are and ever will remain sanctuaries where the little prairie wolf can still lift "to the stars its wonderful, wild

voice and thereby bring back to thousands of lucky visitors the spell of old times, old songs, and old stories, in a way that few ever will forget."—LLOYD TEVIS, JR.

SCIENCE IN ALASKA

Three volumes have now been published covering the Alaskan Science Conferences. The first was reviewed in the October, 1951, issue of the Journal; the other two are reviewed here. There is no duplication of material.

Science in Alaska; Selected Papers of the First Alaskan Science Conference of the National Academy of Sciences, National Research Council. Edited by Henry B. Collins, Arctic Institute of North America, Washington, D. C., 1952, 305 pp. $2.25.

The Zoology section of this publication, pages 258–305, contains information of most interest to wildlife managers. Big game, wildlife resource problems, marine resources and waterfowl are the four subjects covered in broad terms. Olans J. Murie in his paper, "Planning for Alaska's Big Game", presents a strong case for proper land use in the territory. The author urges considerations over and above the single-track approach of wildlife management for harvest by the gun. A few years ago this plea for, "consideration of all the facets of recreation", might have received short shrift. Today sportsmen, photographers, wilderness enthusiasts, and all varieties of nature-loving, scenery-hungry tourists are increasingly recognized as an asset to the territorial economy. Dall sheep, wolf and caribou population fluctuations are mentioned briefly as well as reindeer—caribou competition.

In "Pressing Problems in Administration of Wildlife Resources in Alaska" by your reviewer, three types of problems are described: low production per unit of area, animal behavior and human utilization of the wildlife resource.

"Management of the Marine Resources of Alaska" by Seton H. Thompson begins with this challenging statement:

"Alaska's sea fisheries currently are her most valuable asset. They are the basis for her most important industry, the greatest field of employment for her citizens, and the chief source of her tax revenue. The wealth of the Territory and the welfare of her citizens parallel exactly the success or failure of fishing. Times are good when fishing is good; gloom and depression prevail when fishing is poor."

On a short-term basis, industries associated with military construction: aviation, logging or mining may quibble with Thompson's estimate, but on a long-term basis even these interests will no doubt agree with him. Nationally it has become dictum that where a commercial fishery and a recreational fishery compete for the same species the commercial must give way. In limited areas in Alaska such an incipient conflict is shaping up but when we read Thompson's further words: "The (Alaska) salmon fishery . . . yields two-thirds of the world's entire production of canned salmon"; it becomes clear that sport fishing competition is relatively minor—actually it is limited to two species: king and silver salmon.

General descriptions of the salmon, fur seal, razor clam and halibut status and management occupy the major portion of Thompson's paper. The author's intimate knowledge of the subject will provide readers unfamiliar with Alaska an authentic resume of these resources.

"Alaskan Waterfowl and Their Management" by Ira N. Gabrielson will attract attention of flyway committees and councils as an estimate by one familiar not only with the birds in Alaska but nationally and internationally an authority in the waterfowl field. A brief history of waterfowl observations in the past century is followed by a description of habitat and listing of the important species. Alaska is described as thinly populated with nesting waterfowl over wide areas and heavily populated in other areas such as Yukon-Kuskokwim Delta and Kotzebue Sound. Fall concentration and feeding areas such as Alaska Peninsula, Copper River Flats and Stikine Flats are described. Dr. Gabrielson makes seven recommendations aimed at preserving waterfowl as a source of native food and for contribution to the continental waterfowl resource. (With one minor exception these recommendations have been or are now being acted upon.)

It is noteworthy that one common theme is found in the four papers by different authors: an expressed hope that major mistakes in natural resource management in many of the states, will not be repeated in Alaska.

Science in Alaska; 1951 Proceedings Second Alaskan Science Conference; Alaska Division American Association of Advancement of Science, College, Alaska, 362 pp. 1953, $3.00.

The Wildlife and Zoology section of this publication will be found on pages 303–362. Other sections, however, contain papers of interest to wildlifers, notably: A. E. Porsild's discussion of land use in the arctic, Lloyd Spetzman's paper on arctic slope ecology and an article on interior forests by Ray Taylor.

Noteworthy among wildlife papers is I. T. Cowan's "Plant Succession and Wildlife Management", a concise statement of this relationship in the northern and northwestern part of the continent. The important differences between species such as deer and moose, thriving on early plant successional stages, and caribou and marten requiring climax plant associations is no news to the northern wildlife manager, but it is necessary to bring the difference to the attention of others who tend to generalize from casual knowledge. Cowan concludes that northern wildlife cannot be managed on the basis of the minimum carrying capacity in the most severe winters but instead that, ". . . we must strive to maintain a population level that is somewhere between the carrying capacity of the greatest range area available on mild winters and the smallest available in severe winters."

Of general interest also in R. F. Scott's up-to-date evaluation of the distribution and abundance of Dall sheep in Alaska. This authoritative summary of the sheep situation shows distribution substantially the same today as for the period of recorded history. The greatest variation in distribution through the years occurred on marginal range. Expanding sheep populations occupy marginal range and it is here that sheep numbers decline drastically in the face of adverse factors.

Moving from generalizations to specifics; E. F. Chatelain's paper on winter range of Susitna Valley moose presents the results of field studies in a large area where moose densities ranged from less than one to the mile in mature spruce—birch forests to 5 to 50 odd in the willow stands of the early plant succession following fire.

Other papers of immediate interest to Alaskan wildlifers and passing interest to workers in other areas include: beaver studies by Hakala, waterfowl nesting by Hooper, sea otter by Jones, black bear "hibernation" by Hock, Alaska's biological wealth by Sumner and fur animal problems by your reviewer.

An objective review of *Science in Alaska 1951* should no doubt point out shortcomings in it: spiral binding and not too durable cover, several unnecessary spelling and editing errors. In the wildlife section, papers range from localized studies for Master's degree material to comprehensive resume's of large areas and large problems. For workers in the Territory, however, the overriding advantage is accessibility within one volume of nucleus material as a starting point for additional fact-finding. —W. A. ELKINS.

Records of North American Big Game. The Boone and Crockett Club Committee on Records of North American Big Game (Samuel B. Webb, Chairman). Charles Scribner's Sons, New York and London, 1952; 9 x 6 inches 8vo, pp. i–xiii and 1–178, frontispiece and numerous plates and diagrams.

This is by no means a reprint of the 1939 book "North American Big Game", put out by an earlier Committee. Descriptive chapters on the various species are not repeated. It is instead, a wholly new assessment of the ranking of trophies, on a scientific basis, designed to give weight to beautiful and symmetrical trophies rather than to freaks. In all cases more than one measurement is used for horns and antlers, and in some cases a number are used.

We hope the Committee sticks to its guns on the new system, because it is something that could serve as a basis for the scientific study of horn and antler development. As to trophy collecting, autre jours, autre moeurs! Rooms in which the ensemble will sustain a sixty-five-inch moose head, complete with glass eyes and inflated muffle must nowadays be specially ordered, and effeminate modernity must have set the standard that gives to the mountain sheep the palm that Europe, with its baronial halls, would surely award to the wapiti. In our hunt camp, we must confess, many a buck has been weighed, but none was ever measured. Still, and for all that, nothing

could be more certain than that no really huge rack would ever be discarded. Therein we can see the absolute necessity for the Committee and its book.

Once a system is agreed on, antlers are easy to classify. It is the bears and the cats that cause trouble. Surely they can be handled like fish trophies, and measured before skinning. It is the "length before skinning" in Rowland Ward's list of Bengal tigers that catches the eye. What the walrus tusks are doing in the trophy list we cannot imagine. The narwal's tooth is longer and the walrus trophy usually kept is something quite different. Presumably the Committee broke with their predecessors only when they had to, and what was game in the first list must remain so.—C. H. D. CLARKE.

RECENT PUBLICATIONS

How to Choose and Use Field-glasses. By J. R. Hebditch. Enlarged from an original edition by E. M. Nicholson. British Trust for Ornithology, Field Guide No. 2. 12 pp. Oxford, England, 1953. One shilling.

The author is an ornithologist as well as a dealer in binoculars and telescopes. This pamphlet, together with those published in recent years in Audubon Magazine and American Rifleman by R. J. and E. Reichert, provides information essential to choice and proper use of field optical instruments.

Fall Migration of the Black Duck. By C. E. Addy. U. S. Fish and Wildlife Service, Special Scientific Report: Wildlife No. 19. 63 pp. + 32 figs. processed. Washington, 1953.

An analysis of populations and migrations based chiefly on 15,481 recoveries between 1918 and 1951. Northern populations are strongly migratory, others may be relatively sedentary. Bias introduced by bait-trapping and other recovery factors is discussed.

Yale Conservation Studies. Yale Conservation Club, New Haven, Conn. Vol. 2, No. 1. 100 pp. 1953. $1.00.

A second group of essays (14) from students in the Yale Conservation Program under Paul B. Sears. The effect of this program in emphasizing general problems in the relationship of human beings to natural resources is apparent in several thought-provoking papers. The appearance of the first volume in this series was noted in the *Journal* for October, 1952. Of special interest to your editor were: "The natural history of resource managers" by Gordon Loery and "Two notes on the attitude of farmers" by Richard Lingenfelter (Vol. 1); "Something amiss in the National Parks" by Paul Shepard Jr. and "Culture and technical assistance" by Charles F. Jones (Vol. 2).

Wildlife Research and Management in Scandinavia. By Kaj Westerskov. New Zealand Dept. of Internal Affairs, Wildlife Publication No. 24, 16 pp. 1952.

An excellent general outline of current wildlife investigations in the four countries. Many recent works on population fluctuations, game statistics, food habits and control of wildlife damage and disease are briefly summarized. Problems of administration and management in Scandinavia are compared with those in America and New Zealand.

A Field Guide to the Mammals. By William Henry Burt and Richard Philip Grossenheider. Houghton-Mifflin, Boston. 1952. 200 pp.

The emphasis on this, like others in the "Peterson Field Guide Series" of the Houghton-Mifflin Company, is entirely on recognition characters. Each of 373 species of mammals is treated briefly, usually under the headings of "Recognition" and also "Similar Species." The 24 colored plates portray all of the better known or wider ranging species, and in addition there are hundreds of black and white illustrations, distribution maps for most species, track diagrams, and excellent photographs of representative skulls. The dental formulae, as in the same authors' "Mammals of Michigan," are presented in a particularly useful tabular form. A closing list of "references" presents the most recent book or annotated list of mammals of each state and Canadian province.—G. SWANSON

BRIEFER ARTICLES

CLIFF-NESTING CANADA GEESE ON THE ARCTIC SLOPE OF ALASKA

Urban C. Nelson

176 Behrends Avenue, Juneau, Alaska

During the summer of 1949, Canada geese were observed by pilots, survey crews, and the author on the Colville River, from the headwaters to the 70th parallel on the arctic slope of Alaska. Reports by Eskimos that the geese nest on cliffs of the river was confirmed by locating a single nest and seeing a number of paired birds on the steep north banks. The banks are almost vertical and capped with overhanging tundra. The base continually sloughs into the river during periods of intense flow. The slopes are barren except for scattered bunches of grass and an occasional patch of willow. Climbing the 50- to 300-foot slopes is treacherous. A search of about 10 miles of bank resulted in finding only one nest but geese were flushed from many inaccessible points. The nest (July 9, 1949) was in the open, 45 feet above the turbulent water and 50 feet below a rock ledge. The incubating goose was not flushed but the mate was nearby and left the scene. Geese were seen and flushed from similar locations along the Colville. The cliffs of the Colville are undoubtedly a favorite nesting site of the Canada goose in the Arctic. Non-breeding birds were observed on the river bars. Weights and measurements of five non-breeders, banded on July 12 and 13, identify the species as *Branta canadensis leucopareia*. A survey party located a nest with 6 eggs on the Etivluk River on July 5, 1949.

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Leucocytozoon bonasae IN RUFFED GROUSE; ITS POSSIBLE RELATIONSHIP TO FLUCTUATIONS IN NUMBERS OF GROUSE

Arnold B. Erickson

Minnesota Division of Game and Fish, St. Paul, Minnesota

The ruffed grouse (*Bonasa umbellus*) has been subjected to parasitological studies in Minnesota almost continuously for twenty-one years, 1931–1952. The possible relationship of parasitism to cyclic fluctuations of grouse has been considered in these studies.

Summaries of these investigations have appeared in mimeographed form and in two published articles. Boughton (1937) summarized findings for 560 ruffed grouse collected from 1931 to 1935. Grouse populations in Minnesota were near a peak in 1931 and fell to a low level by 1935. Boughton showed that there was a 37 per cent increase in the percentage of worm-infested grouse from 1931 to 1935. He did not believe worms were responsible for the die-off. The grouse he examined appeared to be in excellent condition.

Erickson *et al* (1949) summarized the findings of examinations of 231 ruffed grouse collected in northern Minnesota from 1941 to 1947, also a period of peak populations declining to a low point. Blood slides from 163 of the grouse were available for study.

Although there was no indication that worm infections were building up in these grouse as populations were declining, there was some indication that the percentage of grouse infected with the blood protozoan, *Leucocytozoon bonasae*, was increasing from 1941 to 1947 and also that the percentage of infection was greater in immature birds than in adults.

If *Leucocytozoon* infection were a factor depressing the grouse population would the percentage of infection decline as grouse began to increase again? To gather information on

this point, 153 grouse were collected from an expanding population between 1948 and 1952, in the same localities where birds were collected from 1941 to 1947. Two blood slides were made from each bird. The findings on *Leucocytozoon* infections for the entire period, 1941–1952, are given in Tables 1 and 2.

During the period 1941–1947 (no blood slides made in 1946), *Leucocytozoon* infections varied from 59.4 to 100 per cent (Table 1). The percentage of infection for the 163 birds examined over the period was 70.5. During the period 1948 to 1952, when there was a great increase in grouse numbers, the infection varied from 50 to 90.5 per cent. For the entire period the percentage of infection

TABLE 1.—INFECTIONS OF *Leucocytozoon bonasae* IN MINNESOTA RUFFED GROUSE, 1941–1952

Year	Number Grouse Examined	Number Grouse Infected	Per cent Infected	Calculated Kill of Ruffed Grouse
1941	30	19	63.3	384,000
1942	49	30	61.2	361,500
1943	30	25	83.3	171,178
1944	32	19	59.4	Closed
1945	3	3	100.0	Closed
1947	19	19	100.0	Closed
Totals:	163	115	70.5	
1948	26	13	50.0	353,840
1949	32	29	90.6	885,309
1950	29	16	55.1	936,351
1951	32	26	81.2	1,420,325
1952	34	24	70.6	1,246,563
Totals:	153	108	70.6	

TABLE 2.—INFECTIONS OF *Leucocytozoon bonasae* IN MINNESOTA RUFFED GROUSE BY AGE CLASSES

Year	Number Young Examined	Number Infected	Per cent Infected	Number Adults Examined	Number Infected	Per cent Infected
1941	26	17	65.4	4	2	50.0
1942	36	22	61.1	13	8	61.5
1943	9	8	88.8	21	17	80.9
1944	24	16	66.6	8	3	37.5
1945	3	3	100.0	..	..	....
1947	16	16	100.0	3	3	100.0
Totals:	114	82	71.9	49	33	67.3
1948	14	8	57.1	12	5	41.6
1949	22	21	95.4	10	8	80.0
1950	26	15	57.7	3	1	33.3
1951	25	19	76.0	7	7	100.0
1952	28	19	67.8	6	5	83.3
Totals:	115	82	71.3	38	26	68.4

for 153 grouse was 70.6, almost identical with the 1941–1947 "period" percentage. During the two periods the percentage of infection showed no definite trend.

The percentage of infection for young birds of the year, and adults during the two periods (Table 2) showed the same trend—a somewhat greater tendency for young birds to be infected.

With data on *Leucocytozoon* infections now available for an eleven-year period covering one whole cycle of ruffed grouse numbers, I conclude that *Leucocytozoon bonasae* is a widespread but relatively harmless parasite of ruffed grouse and probably has no influence on the grouse cycle. I say this, however, with tongue in cheek. Extensive collection of four- to five-week-old grouse chicks might still show that *L. bonasae* and the tapeworms *Davainea proglottina* and *Raillietina tetragona* are very important in causing juvenile mortality.

Another factor which could influence the rate of *Leucocytozoon* infection in grouse is the abundance of black flies (*Simulium venustum*) which serve as a vector for *L. bonasae*. There are no Minnesota records, however, of variations in the abundance of these flies (Nicholson and Mickel 1950).

The Minnesota information to date, then, is largely a record of the percentage of infection of *L. bonasae* in ruffed grouse over a period of years. It is evident that controlled laboratory experiments with *L. bonasae* and avian hosts are necessary if more is to be learned about this parasite and its effect on the host.

In conclusion it should be noted that Clarke (1935), in studying the die-off of ruffed grouse in Ontario, presented presumptive evidence that *L. bonasae* was possibly responsible for widespread mortality of young birds. He cautioned, however, against jumping to conclusions until further experimental work had been done.

Fallis (1945) reported on the examination of 51 ruffed grouse collected in 1942 (59% infected with *L. bonasae*) and 55 collected in 1943 (67% infected with *L. bonasae*). He detected four other species of blood parasites in these birds and raised the question of their pathogenicity.

I am indebted to Milton Stenlund, Vernon Gunvalson, and Walter Petraborg for assistance in collecting grouse and making blood smears. Dr. Henry J. Griffiths and Dr. T. Jensen, University of Minnesota, stained and examined the blood slides collected from 1948 to 1952.

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THE USE OF A DICTATING MACHINE TO RECORD AERIAL OBSERVATIONS

Walter F. Crissey

Fish and Wildlife Service, Washington 25, D. C.

In recent years, workers in wildlife research and management have developed many uses for the airplane, particularly as an efficient means of making many types of surveys. Most of these surveys involve the recording of data, and a frequent difficulty has been that more observations could be made in a short time than could be recorded properly.

Waterfowl breeding-ground surveys conducted by a pilot and an observer constitute a good example. Because counting and identifying ducks requires flight at low altitudes, it is not considered a safe practice for the pilot to turn his attention from outside the plane long enough to keep a hand-written record of birds he may see. This gives the observer the responsibility of recording his own observations plus those of the pilot. In areas of medium to high waterfowl density it is not possible for the observer to record all data collected and also cover the ground on his side of the plane adequately. As a result, information is lost and accuracy impaired.

There are other types of low-altitude surveys during which the pilot alone would be able to collect all information needed. Because of necessity for paying constant attention to flying the plane, however, a second person is required to keep records.

A solution to the problem of recording a large volume of data in a short time without dividing attention between inside and outside the plane lies in the use of a dictating machine. Several types have been tried in years past but these machines have been mostly unsatisfactory, usually because of mechanical unreliability, low quality of reproduction, or lack of adaptability for use in a plane. During the summer of 1952, however, a dictating machine was used successfully during an extended waterfowl breeding-ground survey. The machine and type of installation used apparently have made it possible to overcome most of the previous difficulties. (Fig. 1.)

The dictating machine used in the 1952 survey was the Time Master Model TA, manufactured by Dictaphone. By making one minor change in wiring, it is possible to attach earphones so that a person talking into the microphone can hear a side-tone. This feature alone increases the adaptability of a dictating machine for use in a plane. In the first place, the Time Master Model is so constructed that if a side-tone can be heard, there is little chance that the record is not being properly cut. The importance of this feature cannot be underrated, since one of the chief drawbacks in the past has been that a malfunctioning machine was often undetected until the end of a flight. Secondly, the ability to hear what is being dictated makes it possible for more than one person to dictate into the same machine without looking to see whether it is in use. With two microphones and two sets of earphones attached to the machine, the pilot and observer found that its operation was similar to the intercommunication system of a plane, or an ordinary telephone, except that everything said was recorded.

Clarity and understandability in playing back recordings were uniformly excellent. The Dictaphone can be adjusted for volume of sound necessary to make a recording. This adjustment could be set so that the noise level in the plane would not record, while an ordinary tone of voice spoken into a microphone held close to the lips would come through clearly.

The model used employs, for recording purposes, a plastic belt with space for 15 minutes of dictation. During the summer all types of data were recorded, including each duck or group of ducks seen, descriptions of habitat types over which the survey was made, description of the area covered, and location and data pertaining to all photographs. About 400 individual waterfowl observations and 50 or more comments and descriptions could be recorded on a single belt. In the areas worked, this was sufficient for a flight of about 3 hours duration, and a new belt could easily be placed in the machine while the plane was in the air. Although Dictaphone manufactures a similar model which will take 30 minutes of dictation

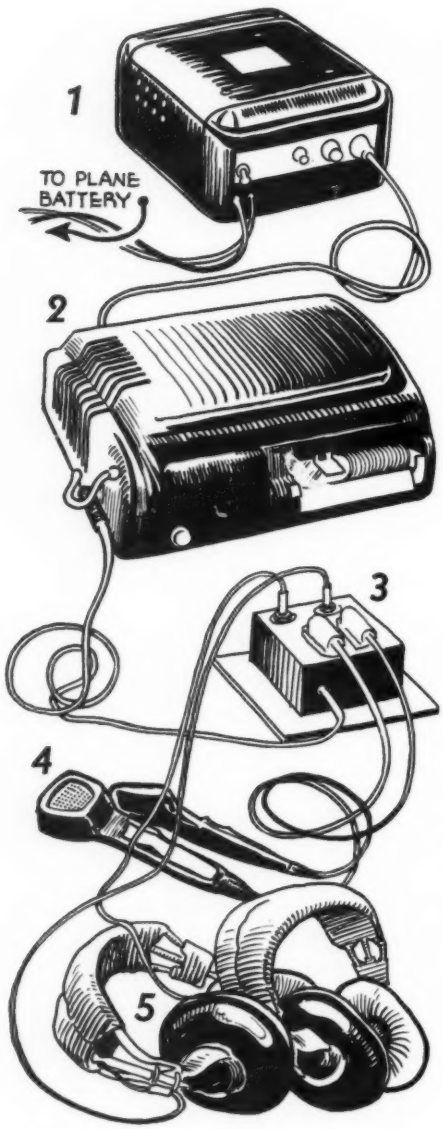

FIG. 1. Installation of dictating equipment used in aircraft. (1) Power Inverter—12 volt DC to 110 volt AC, ATR Manufacturing Corp. (for the purpose of adapting the Dictating Machine to the 12 volt power supply in the plane); (2) Dictating Machine—Time Master Model TA, Dictaphone Corp.; (3) Junction Box—Custom built for the purpose of attaching two microphones and two sets of earphones to the same dictating machine; (4) Microphones, magnetic type (2); (5) Earphones, standard aircraft radio type (2).

on a single belt, the 15 minute belt seemed adequate for the purpose and permitted a simpler filing system after the work was done. There is a special pencil with which filing information can be written directly on the belts. Belts are mailable, which can be an advantage in some circumstances.

The Time Master Model has a play-back arrangement, controlled by the microphone, which allows for transcription of data in the field without extra equipment. If prepared form sheets were used, waterfowl data on a 15-minute belt could be transcribed in about 20 minutes. The machine fits into a compact carrying case which makes a convenient piece of hand luggage for transporting to and from places of lodging. With the inclement weather which usually interrupts extended aerial surveys, it was not difficult to keep up to date in transcribing records.

During the period when the method of installing a dictating machine in a plane was being developed, it was determined that the Gray Audograph could be adapted for use in exactly the same manner as the Dictaphone; and there may be other machines which can be used equally well. As far as could be determined, the two machines offered little difference in reliability or quality of reproduction. The Audograph employs a plastic disc for recording purposes, and this disc in some respects seems more convenient than the belt employed by Dictaphone. The Dictaphone was selected because it is somewhat more compact and moving parts are less exposed, both features being advantageous in small planes.

Although cost of the equipment is high (about $525), the advantages are many and the use of a dictating machine for recording aerial observations is highly recommended.

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UNISEXUAL BROODS OF THE MOURNING DOVE

Charles W. Kossack and Harold C. Hanson
Illinois Natural History Survey, Urbana, Illinois

In 1948, the Illinois Natural History Survey initiated a comprehensive investigation of the mourning dove (*Zenaidura macroura*). Certain phases of this research involved the rearing of young birds in captivity. This was accomplished at first by taking half-grown young from nests in the wild and rearing them by hand; later, the original captives produced young. In this manner, complete sex data were obtained over a period of three years on 21 broods. A review of these data revealed that the two young birds in each brood were of the same sex. Because this finding departed so far from the expected, it seemed advisable to report it to other observers at an early date.

The writers are indebted to Dr. C. C. Morrill of the University of Illinois College of Veterinary Medicine for sexing by tissue section some of the nestlings and immature birds that had died and were held in preservatives.

Of the 21 broods recorded, 13 were composed of two males each, and 8 contained two females each. The expected sex ratio of broods of two young each would be in the ratio of 1:2:1 as in pigeons (Levi, 1941) with broods containing both sexes comprising 50 per cent of the total number of broods. The data herein reported, however, when subjected to the X^2 test, revealed that it was very unlikely for 21 unisexual broods to be encountered purely on the basis of chance. Additional data are needed, of course, to determine the over-all secondary sex ratio, but if the present finding of unisexual broods is substantiated, our understanding of dove populations may be profoundly modified.

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RECUPERATIVE RATE OF WING-SHOT MALLARD

Burd S. McGinnes and Robert A. Beck
Delaware Game and Fish Commission, Dover, Delaware

The waterfowl hunting season in Delaware for 1952 closed on December 24. December 27 and 28 brought cold weather which solidly froze the marsh areas.

An impounded "Thousand-Acre Marsh" in New Castle County had sustained a heavy hunting pressure and an abundance of crippled ducks became evident when the marsh froze. Boys who were ice skating on December 28 were able to capture three ducks out of a larger number of cripples and these were turned over to a local Delaware wildlife technician. These birds were banded with U. S. Fish and Wildlife Service bands on December 30, 1952 and released on the tide-water side of the impounded marsh.

All three of these ducks had broken left wings. A female black duck had the wing bone well knitted but was still flightless. A female mallard was flightless because the break had not yet healed. The third duck, another female mallard, had apparently sustained her injury the latter part of the hunting season since the left humerus was protruding from the wing and the sharp end of the bone caused a puncture wound and bleeding. This bleeding was fresh at the time of banding and release.

When put into the tide water ditch the latter bird quickly swam to the bank and attempted to hide. She was again placed into the water and again immediately took refuge in a dense stand of giant cord grass. This was not the action displayed by the two lesser wounded birds which preferred to stay in water.

The badly crippled mallard female was returned to the banders by a muskrat trapper on January 12, 1953. The bird had been caught

in a muskrat trap and was dead from drowning. Examination of the duck revealed that in the thirteen days subsequent to banding and release the broken wing had begun to mend. The bone ends had fuzed and there were no external indications of the severe break so much in evidence less than two weeks earlier.

It was the opinion of the authors that this bird would have been capable of flight in another month. While this observation of gunshot crippling of waterfowl is a single instance, it demonstrated rapid recuperative power in spite of adverse weather and poor condition.

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A RAPID METHOD OF SEXING CANADA GEESE

Lewis B. Turner

P. O. Box 297, Manteo, North Carolina

In recent years, determination of both age and sex of waterfowl by cloacal examination has come into widespread use in wildlife investigations. Although reasonable accuracy in sex determination is possible, this method is time-consuming and laborious, for with geese it involves everting the margin of the vent of a strong and invariably uncooperative bird. The possibility of permanently damaging the developing genitalia of the young birds as a result of this necessarily rather rough handling also must be considered.

During the past two winters of 1950–51 and 1951–52, nearly 1,500 Canada geese were trapped at Pea Island National Wildlife Refuge in Dare County, North Carolina, in connection with biological studies which were in progress on this species. With an increased familiarity acquired through continuous handling of the geese, physical differences of the sexes became evident. The most obvious difference between the sexes of 415 Canada geese was their weight, averaging 8.6 pounds for males and 6.7 pounds for females, a difference of 1.9 pounds. Although this difference was applicable to the majority of geese examined, it cannot be considered an infallible method in sexing geese, since a substantial proportion of both sexes has overlapping weights, and some of the larger females exceed the lighter males in weight.

A character which proved to be a much more reliable criterion than the weight involved is the sexual difference in the profile of the Canada goose's head between the tip of the bill and the junction of forehead and crown. This difference is demonstrated in the accompanying Figure 1, which shows the male

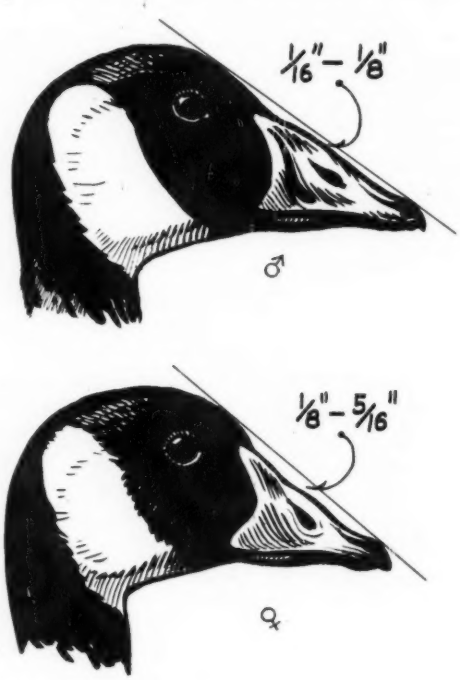

FIG. 1. A diagrammatic comparison of the forehead and culmen profiles of male and female Canada geese.

to have a more wedge-shaped bill and forehead, while with the female the profile is distinctly more concave. This profile difference is readily demonstrated by laying a rule or other straight-edge against the bill and fore-

head. The clearance between bill and rule in the male is very slight, and is one-eighth inch or less. With the female, this clearance exceeds one-eighth inch, and may range up to five-sixteenths inch. Consequently, by this method of sex determination, Canada geese with a profile concavity one-eighth inch or less are classed as males, while those with a more pronounced concavity exceeding one-eighth inch are classed as females.

Another external feature in male birds which becomes more pronounced with age is a callosity or rounded protuberance that develops on the anterior edge of the wing at the wrist joint, in close affinity with the distal head of the radius. This knob possibly develops as a result, at least in part, of wing-beating skirmishes between males, especially before the breeding season. The callous is missing on females and juvenile birds. The mature female, however, is distinguishable from the mature male by the relatively smoother-scaled tarsi and metatarsi of the former in contrast with the rougher-scaled feet of the male. Although these characters are diagnostic, their use in sex determination should be exercised only with the relatively small proportion of geese having intermediate profile measurements, or in occasional verification of routine sex determination of Canada geese.

As with many other wildlife study techniques, employment of the above described characters in determining the sex of a Canada goose almost "at a glance" becomes more rapid and accurate with increased experience of the technician. Among 415 geese sexed by both cloacal examination and the present method that involves examination for the straightness of the forehead and culmen profile, as well as the presence or absence of the wrist-joint callosity, individual weight, and the degree of roughness of the scales of the feet, the accuracy of both techniques seemed similar. The degree of accuracy of the present method, however, will best be determined by its use at checking stations during the hunting season when large numbers of Canada geese may first be sexed by these characters, and then rechecked by exposing the internal organs for positive sexual determination. This feature is less reliable with juvenile birds, and any percentage of error by this technique appears largely concerned with the younger age categories of Canada geese not yet sexually mature. For field use, it is believed to be at least as accurate as the cloacal examination method, especially when sexing adults on breeding areas. The principal advantage of this technique is its speed, requiring only a small fraction of the time involved when using the older method. Although this technique was developed at Pea Island Refuge for use with the larger Canada geese, modifications of it may apply with the smaller subspecies such as the lesser Canada goose and cackling goose, and possibly with other species such as snow goose, blue goose and both species of brant.

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THE WILDLIFE SOCIETY
NOMINATIONS FOR SOCIETY OFFICERS, 1954-55

The Committee on Nominations has prepared the following slate of nominees to be voted on for the period of office in 1954-55.

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A. Starker Leopold

Vice-President
Kenneth D. Carlander
Thomas R. Evans

Regional Representatives

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Region II:	Leonard Foote Eugene Wallace	Region VI:	J. B. Lauckhart J. B. Low
Region III:	D. W. Douglass S. C. Whitlock	Region VII:	C. David Fowle Ian McT. Cowan
Region IV:	Lee E. Yeager Ralph Hill		

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